Electronic Services - Hayward, Ca
M17294X

CALIFORNIA INSTRUMENTS
a division of
AIKEN INDUSTRIES, INC.

5150 Convoy St. • San Diego, Ca. 92111 • (714) 279-8620 • Cable: CALICO SANDIEGO • telex: 695047

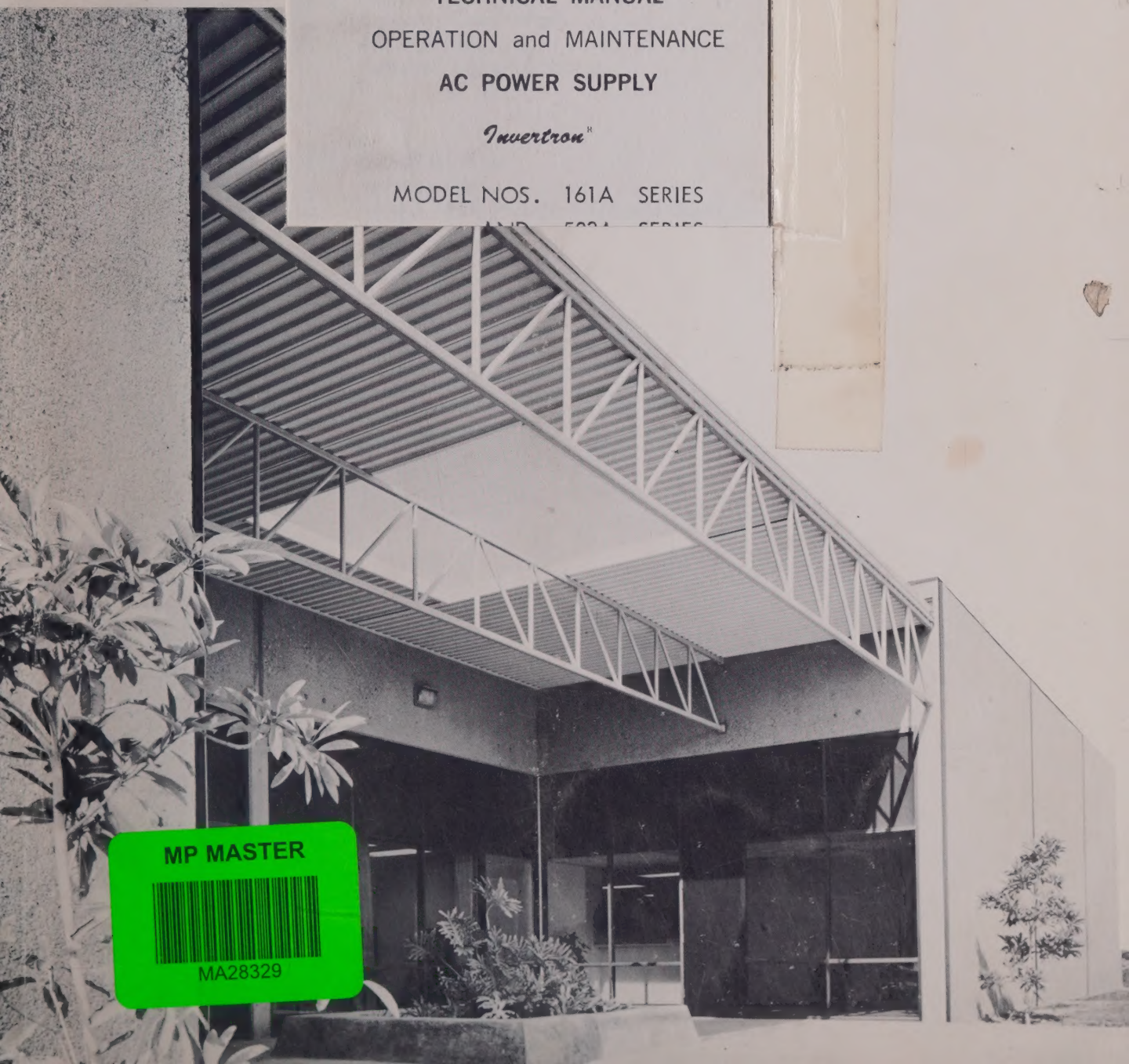
TECHNICAL MANUAL

OPERATION and MAINTENANCE

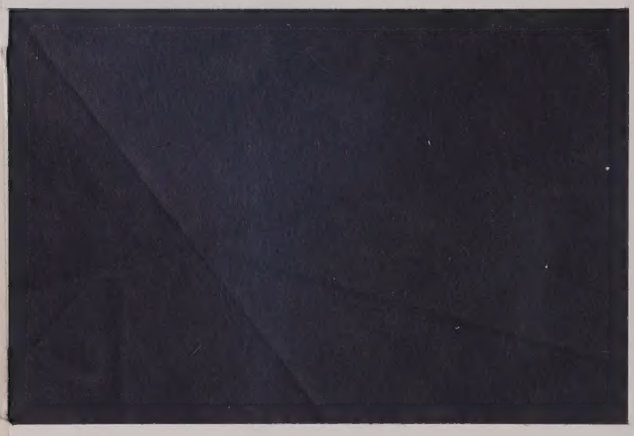
AC POWER SUPPLY

Invertron®

MODEL NOS. 161A SERIES



MP MASTER
MA28329



TECHNICAL MANUAL

OPERATION and MAINTENANCE

AC POWER SUPPLY

Invertron®

MODEL NOS. 161A SERIES
AND 503A SERIES

REV. JANUARY, 1968

CALIFORNIA INSTRUMENTS CORPORATION, a division of Aiken Industries, Inc.
5150 Convoy Street
San Diego, California 92111

TABLE OF CONTENTS

Section			Page
1	INTRODUCTION AND SPECIFICATIONS		
	1-1.	Identification and General Description	1
	1-3.	Model 161A Invertron	1
	1-4.	Model 503A Invertron	1
	1-5.	Specifications and Performance Data	1
	1-7.	Frequency-Determining Signal Sources	3
	1-8.	Plug-In Oscillators	3
	1-9.	External Oscillators	4
	1-10.	Preamplifier	4
	1-11.	External Signal Adapter	4
2	CIRCUIT DESCRIPTION		
	2-1.	Introduction	7
	2-3.	Model 161A Invertron Circuit Description	7
	2-6.	Phase Inverter	7
	2-7.	Cathode Follower/Drivers	9
	2-8.	Power Amplifier	9
	2-9.	Feedback Circuits	9
	2-10.	Output Meter Circuit	9
	2-11.	Output Circuit Overload Protection	10
	2-12.	Model 161A Integral Power Supply Circuits	10
	2-14.	Primary A-C Power Input Circuit	10
	2-16.	The +645 Volt Power Supply Circuit	11
	2-17.	Regulated Power Supply	11
	2-18.	Bias Power Supply	11
	2-19.	Model 503A Invertron Circuit Description	11
	2-21.	Oscillator Input and Power Circuits	11
	2-22.	Output Meter Circuit	11
	2-23.	Output Circuit Overload Protection	13/14
	2-24.	Primary A-C Power Input Circuit	13/14
	2-25.	Primary A-C Power Input Voltage Range	13/14
	2-26.	Cooling Fans	13/14
3	OPERATION		
	3-1.	General	15
	3-3.	Input Signal Source	15
	3-5.	Power Input and Power Output Circuit Connections	15
	3-9.	Controls and Indicators	20
	3-12.	Preliminary Checks and Adjustments	21
	3-14.	Checks and Adjustments of the Model 161A	21
	3-15.	Checks and Adjustments of the Model 503A	22
	3-16.	Operating Procedure	23/24
4	MAINTENANCE		
	4-1.	General	25
	4-3.	Test Equipment	25
	4-5.	Periodic Preventive Maintenance	25

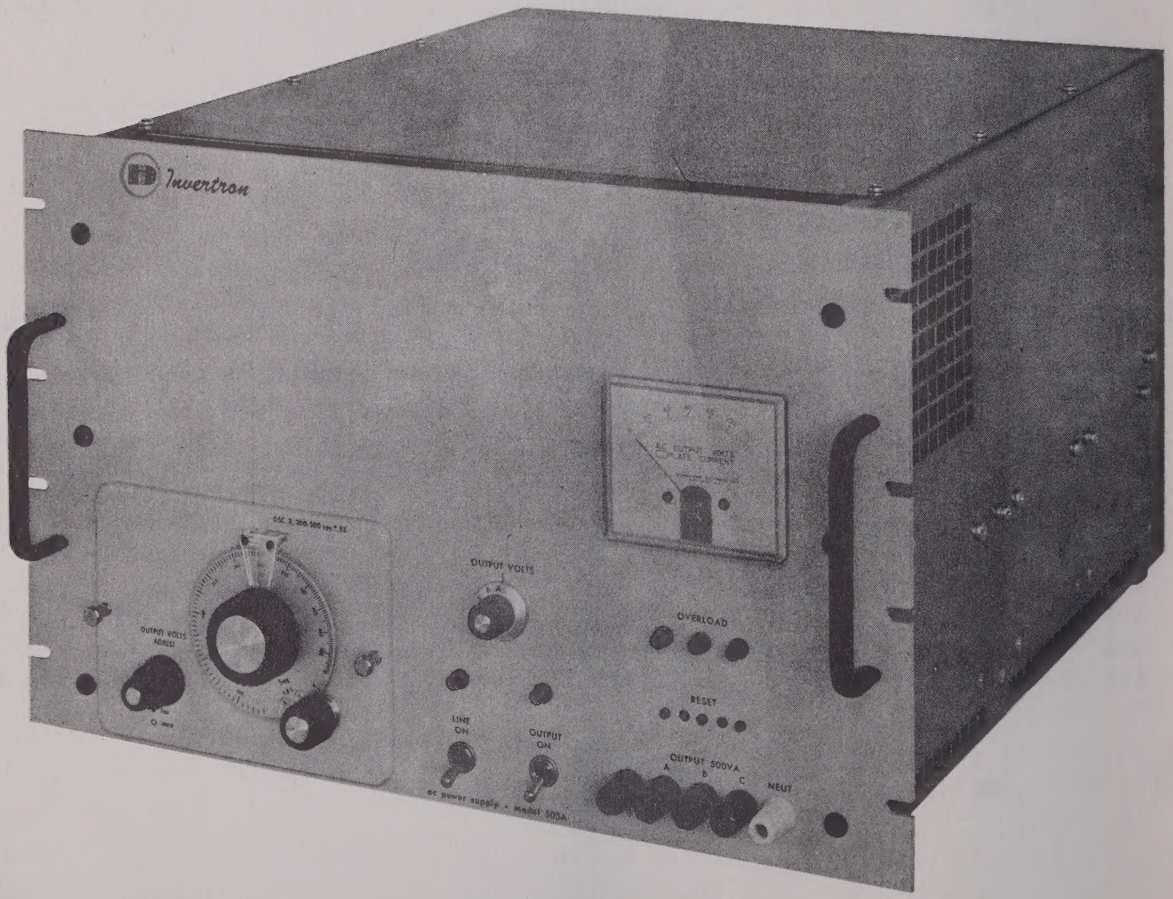
TABLE OF CONTENTS (Continued)

Section		Page
4	MAINTENANCE (continued)	
	4-6. Inspection	25
	4-7. Cleaning	25
	4-8. Output Voltage Adjustment	28
	4-9. Bias Adjustment	28
	4-10. Model 161A Gain Control Adjustment	28
	4-11. Model 503A Gain Adjustments	28
	4-12. Troubleshooting	29
	4-14. Voltage and Resistance Measurements	29
	4-15. Circuit Faults Not Affecting Voltage and Resistance Measurements	31
	4-16. Repair and Replacement	32
	4-17. Lubrication	32
	4-18. Lubrication of Model 161A Fan Motor	32
	4-19. Lubrication of Model 503A Fan Motors	32
	4-20. Shut-Down Procedure	33/34
5	PARTS LIST	
	5-1. Introduction	39
	5-3. Vendors' Codes	39

LIST OF ILLUSTRATIONS

Figure No.		Page
1-1	Model 161A and Model 503A Invertron AC Power Supplies	v
2-1	Model 161A Invertron, Block Diagram	8
2-2	Model 503A Invertron, Block Diagram	12
3-1	Model 161A Invertron, Rear View, Cover Removed	16
3-2	Model 503A Invertron, Rear View, Cover Removed	16
3-3	Model 161A Invertron, Top View, Cover Removed.	17
3-4	Model 503A Invertron, Bottom View	18
4-1	Model 503A Invertron, Top View, Cover Removed	26
4-2	Printed Circuit Board Assy, Part No. 4001843 (For Mod 161A and 503A)	27
4-3	Model 161A Invertron, Schematic Diagram	35/36
4-4	Model 503A Invertron, Schematic Diagram	37/38

Model 161A



Model 503A

Figure 1-1. Model 161A and Model 503A Invertron AC Power Supplies

SECTION 1

INTRODUCTION AND SPECIFICATIONS

1-1. IDENTIFICATION AND GENERAL DESCRIPTION

1-2. This manual provides a general description, theory of operation, and operating and maintenance instructions for Darcy Invertron AC Power Supplies Model 161A and Model 503A (see Figure 1-1). This manual also contains schematic diagrams (see Figures 4-3 and 4-4) and a list of replaceable parts for both the Model 161A and the Model 503A Invertrons.

1-3. MODEL 161A INVERTRON. The typical Invertron, as exemplified by the Model 161A unit, consists of a plug-in frequency-determining oscillator, an a-c power amplifier, and an integral rectifier-type d-c power supply, which provides necessary operating voltages for the circuits of the oscillator and the power amplifier. The Model 161A Invertron produces a single-phase output, the frequency of which is determined by the output frequency of the plug-in oscillator; the power amplifier being operable over an input frequency range of 45 to 5000 Hz. (For information regarding plug-in oscillators and external oscillator adapters that are available for use with the Model 161A Invertron, refer to paragraphs 1-8 through 1-11.) As supplied normally, the Invertron is powered by a 117-volt, 50/60 Hz, single-phase a-c input. However, the unit will accommodate 50/60 Hz, single-phase inputs of 208, 220, or 230 volts, when connections to the power transformer and the value of the a-c line fuse are changed as indicated in Figure 4-3 and in Table 3-1. The output of the Model 161A is continuously variable over a range of 0 through 130 vac. The maximum output power of 160 va is available over an output voltage range of 100 through 130 vac. Power amplifier design minimizes output voltage waveform distortion and provides excellent voltage regulation over a wide range of input voltage and output load variations. The Model 161A Invertron is readily adaptable to cabinet or rack mounting.

1-4. MODEL 503A INVERTRON. The Model 503A Invertron consists essentially of the circuits of three Model 161A Invertrons incorporated on one common chassis. These circuits enable the Model 503A to produce either a 2-phase or a 3-phase output, depending upon the nature of the input from the associated plug-in oscillator. Both the 2-phase and the 3-phase outputs are continuously variable from 0 through 130 vac, with the maximum power outputs of 330 va and 500 va, respectively, being available over an output voltage range of 100 through 130 vac. The Model 503A can also produce three individual single-phase outputs (each identical in characteristics to the output of the Model 161A Invertron) when its power amplifiers are driven by an oscillator providing single-phase outputs. (Refer to paragraphs 1-8 through 1-11 for information concerning plug-in oscillators and external oscillator adapters available for use with the Model 503A Invertron.) In common with the Model 161A Invertron, the Model 503A Invertron is normally supplied with the primary power input circuits arranged to permit operation with a primary power input of 117-volt, 50/60 Hz, single-phase a-c. However, the Model 503A may be altered for operation with inputs of 208, 220, or 230-volt, 50/60 Hz, single-phase a-c as indicated in the schematic diagram of Figure 4-4 and in Table 3-1. The Model 503A Invertron, also, is readily adaptable to cabinet or rack mounting.

1-5. SPECIFICATIONS AND PERFORMANCE DATA

1-6. Refer to Table 1-1 for specifications and performance data.

TABLE 1-1

SPECIFICATIONS AND PERFORMANCE DATA

Electrical Specifications	
Power Requirements:	117 vac +10% single-phase, 47-63 Hz (208, 220, 230 vac single-phase, 50/60 Hz, input available on request)
Output Power:	
Model 161A	160 va 1 phase, ±0.7 PF Load
Model 503A	330 va 2 phase, ±0.7 PF Load 500 va 3 phase, ±0.7 PF Load
Model 161A Output Voltage:	
Overall Range:	0-130 v or on special order 0-30 v; full power, 23-30 v
Range Over Which 160 va Available:	100-130 v
Model 503A Output Voltage:	
Overall Range:	0-130 v or on special order 0-30v; full power, 23-30 v
Range Over Which Maximum Power Available:	
330 va (2 phase):	100-130 v
500 va (3 phase):	100-130 v
Amplifier Frequency Response:	45 Hz to 5 KHz
Frequency-Determining Signal Requirement:	15 v rms, 45 Hz to 5 KHz
System Distortion (with typical oscillator):	0.9% maximum over entire frequency range at full power; 0.4% maximum at mid-band
Amplifier Distortion:	0.3% maximum over frequency range at full power
Regulation: vs Line:	+0.5% for +5% line at full power, ∓ 1% for ∓10% line at 3/4 power
vs Input Frequency:	±0.5%
vs Load:	1% max for no-load to full-load. Potentiometer provided for adjustment of load regulation; can be set for 0.5% regulation for specific line and load conditions.
Recovery Time:	Zero (maximum load transient does not exceed regulation band)

TABLE 1-1

SPECIFICATIONS AND PERFORMANCE DATA (Continued)

Electrical Specifications (continued)		
Short Circuit Protection:	Supply is protected from output short circuit by means of thermal circuit breakers.	
Output Noise:	60 db below full output voltage or 60 mv rms, whichever is greater.	
Output Connections:		
Model 161A	Single-phase, 3-wire	
Model 503A	3-phase; either line-to-neutral or line-to-line output can be furnished. (Line-to-neutral is standard, line-to-line must be specified if desired.)	
Mechanical Specifications:		
	Model 161A	Model 503A
Width:	19 inches	19 inches
Height:	5.25 inches	12.25 inches
Depth Behind Panel:	16.62 inches (including fuse holder)	20 inches
Weight:	50 pounds (less oscillator)	125 pounds (less oscillator)
Environmental Specifications:		
Ambient Temperature Range:	0 to 45°C	
Means of Cooling:	Forced air	

1-7. FREQUENCY-DETERMINING SIGNAL SOURCES

1-8. PLUG-IN OSCILLATORS. The Model 161A and 503A Invertrons normally employ plug-in oscillators to provide input signals of the required frequency and to enable control of the Invertron output power. All a-c and d-c power requisite for operation of the plug-in oscillators is supplied by circuits of the associated Invertron. Darcy Industries can supply standard or special plug-in oscillators to provide fixed or variable frequencies in 1, 2, or 3 phases. Two lines of oscillators are available; either vacuum tube or completely transistorized versions can be supplied. Specifications for the standard oscillators are contained in Table 1-2. For ordering purposes, the plug-in oscillator model numbers are established as follows:

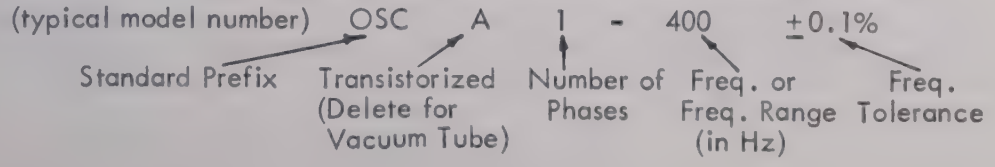

(typical model number) OSC A 1 - 400 ±0.1%
Standard Prefix
Transistorized (Delete for Vacuum Tube)
Number of Phases
Freq. or Freq. Range (in Hz)
Freq. Tolerance

TABLE 1-2

STANDARD PLUG-IN OSCILLATOR UNITS

(Vacuum Tube)

TYPE	FREQUENCY RANGES AVAILABLE	FREQUENCY ACCURACIES AVAILABLE	PHASE AVAILABLE
Fixed Frequency Oscillator*	Any single frequency 45-5000 Hz	0.1%, 0.01%, or 0.001%	1, 2, or 3
Continuously Variable Frequency Oscillator*	1 Octave Band: 300-600 Hz	0.5%	1, 2, or 3
Continuously Variable Frequency Oscillator	4 Bands: 45 - 150 Hz 150 - 500 Hz 450 - 1500 Hz 1500 - 5000 Hz	1.0%	1, 2, or 3

* Single-phase models equipped with a front panel jack for external oscillator input.

(Transistorized)

Some of the transistorized plug-in oscillators (OSC A Series) available are as follows:

Single Octave Bands; i.e., 300-600 Hz, 45-90 Hz, etc.

Special Bandspread Versions; i.e., 45-75 Hz, 300-500 Hz, 700-900 Hz, etc.

Continuously Variable; i.e., 45-5000 Hz in 4 Bands

1-9. EXTERNAL OSCILLATORS. Through the use of accessory plug-in units, the Invertron can accommodate frequency-control inputs from a variety of external signal sources. As noted in Table 1-2, with the exception of the continuously variable frequency, 45-5000 Hz plug-in oscillator, all standard single-phase plug-in oscillators are provided with a front panel mounted, closed-circuit jack to accept inputs from external signal sources. When an external input signal is connected to this jack, the OUTPUT VOLTS ADJ control of the plug-in oscillator retains its normal function.

1-10. PREAMPLIFIER. Also available for use with an external oscillator is the Darcy plug-in Preamplifier Assy Model PRE-1. This unit, which will accept signals in the 45-5000 Hz frequency range, provides a voltage gain of 15 with a 1.0-volt (RMS) input signal. The Preamplifier derives all necessary operating voltages from the associated Invertron and is provided with both coarse and fine Invertron output voltage adjustment controls.

1-11. EXTERNAL SIGNAL ADAPTER. External Signal Adapter Assy Model EXT-45/5 KHz is a plug-in unit that permits application of an external frequency-control signal to the Invertron without providing for controllable modification of the signal characteristics. Since the adapter

is not provided with an output level control, the external signal source must be equipped with an output level control, it not being possible to establish any desired Invertron output voltage level in the absence of such a control. (Note that the plug-in units described in paragraphs 1-9 and 1-10 permit use of frequency-control signal sources that have fixed output levels.)

SECTION 2

CIRCUIT DESCRIPTION

2-1. INTRODUCTION

2-2. The power amplifier circuits of the Model 503A Invertron are identical to the power amplifier circuit of the Model 161A Invertron. Therefore, the descriptions of the Model 161A (paragraphs 2-3 through 2-18) will, with the exception of the output circuit descriptions (paragraphs 2-10 and 2-11) apply to the power amplifiers of the Model 503A Invertron. Circuit descriptions for the Model 503A are contained in paragraphs 2-19 through 2-26.

2-3. MODEL 161A INVERTRON CIRCUIT DESCRIPTION

2-4. The Model 161A Invertron (see Figure 2-1) is comprised of an input signal source (normally, a plug-in oscillator), a 160 va power amplifier, two rectifier-type d-c power supplies, and monitoring and protective circuits. Circuits of the 160 va power amplifier include a phase inverter stage, two cathode follower/drivers, and a 6-tube push-pull parallel output stage; the circuits comprise a conventional audio frequency amplifier, which serves to increase the power of the input signal from the plug-in oscillator to the required level of approximately 160 va. Inclusion of a negative feedback loop between the output stage and the phase inverter input stage of the power amplifier results in increased power amplifier stability and linearity of frequency response. A thermal circuit breaker in the output circuit of the power amplifier protects that circuit from possible damage occasioned by short circuits. An integral voltmeter is connected across the output circuit of the power amplifier to facilitate establishment of the desired Invertron output voltage. The internal power supply circuits provide outputs of 6.3 vac, and regulated high voltage d-c for application to the circuits of the power amplifier and the plug-in oscillator.

2-5. The individual circuits (see Figure 4-3) which perform the previously described functions are detailed in the following paragraphs. Many of the circuits are conventional and, therefore, do not merit detailed descriptions.

NOTE

Since the input signal of the Invertron may be derived from any one of several plug-in oscillators, or from other signal sources, no detailed descriptions of signal sources are contained in this manual. In those cases where the input signal source is one of the Darcy plug-in oscillators, refer to the instruction manual supplied with the oscillator for a detailed functional description of its operation.

2-6. PHASE INVERTER. The phase inverter consists of pentode tubes V1A and V2A and associated components. The cathodes of these pentodes are connected through common cathode bias resistor R55 to the -105-volt supply. The screen grids also are parallel-connected, and are maintained at a potential of somewhat less than +150 volts by voltage divider resistors R7 and R8. Resistors R5 and R6 form the plate loads for tubes V1A and V2A, respectively. The input signal is applied to the control grid of V2A via resistor R56. The signal appearing across common cathode resistor R55 is in phase with the signal at the control grid of V2A and out of

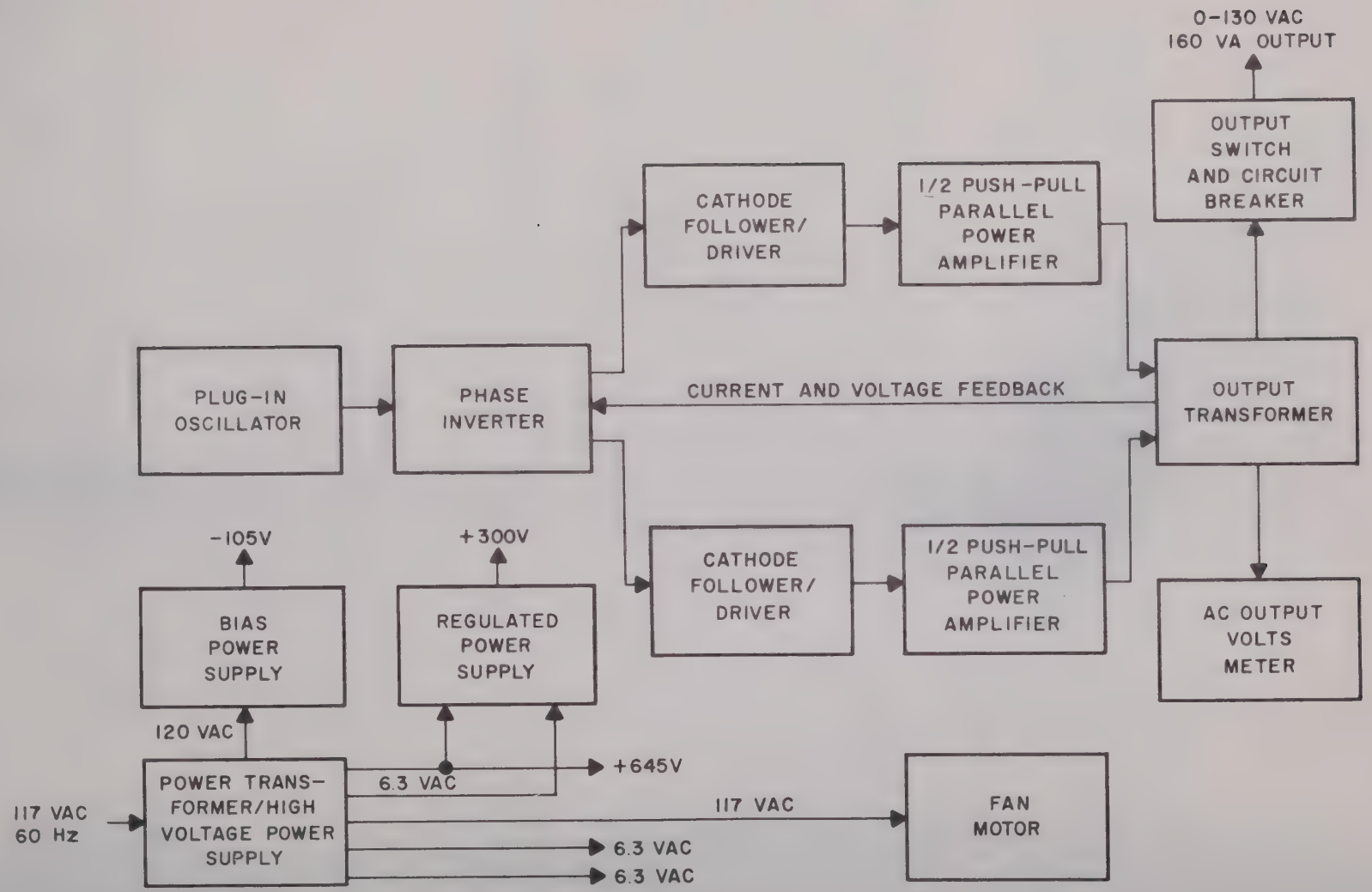


Figure 2-1. Model 161A Invertron, Block Diagram

phase with the signal at the plate of V2A. The signal across R55 is applied to the cathode of V1A and produces a signal across the plate load of that tube in phase with the input signal. Thus, the signals appearing at the plates of V1A and V2A are 180° out of phase and equal in amplitude. The feedback signal developed in the power amplifier output circuit (refer to paragraph 2-9) is applied to the control grid of V1A, and also causes corresponding out-of-phase signals to appear at the plates of V1A and V2A. Tubes V1A and V2A, because of the common cathode circuit, operate as a differential amplifier, and a "single-ended" signal applied to either control grid produces a push-pull signal across the two plate load resistors. The cathodes of V1A and V2A are connected to the -105-volt supply to make the effective plate voltage 405 volts and, therefore, provide a greater dynamic range over which the tubes can be operated linearly.

2-7. CATHODE FOLLOWER/DRIVERS. The cathode follower/driver circuits include tubes V1B and V2B, and associated circuit components. The push-pull output signals of stage V1A and V2A are applied to the grids of V1B and V2B via capacitors C2 and C3, respectively. The plates of the cathode followers are connected directly to the +300-volt source, while the cathodes are connected via cathode load resistors R15 and R16 to the -105-volt source. Control grid bias for V1B and V2B is developed by the voltage divider network composed of resistor R10, A-1 BIAS ADJ control R13, and A-2 BIAS ADJ control R15. The A-1 BIAS ADJ and A-2 BIAS ADJ controls are adjusted to produce quiescent voltages on the cathodes of V1B and V2B, respectively, that equal the negative bias potentials required by the power output tubes; this adjustment being made possible by the direct coupling between the cathodes of V1B and V2B and the control grids of output tubes V3, V5, and V7, and V4, V6, and V8, respectively.

2-8. POWER AMPLIFIER. The power amplifier stage consists of pentodes V3 through V8, output transformer T102, and associated circuit components. Tubes V3 through V8 are connected in a conventional class AB, push-pull, parallel amplifier circuit. The output of cathode follower/driver stage V1B is connected to the control grids of paralleled amplifier tubes V3, V5, and V7 through isolating resistors R17, R19, and R21, respectively. Chokes L1/L2, L3/L4, L5/L6, L7/L8, L9/L10, and L11/L12 provide parasitic suppression in the plate circuits of tubes V3 through V8. Each of these chokes consists of a pair of ferrite sleeves, which is slipped over the plate lead of the associated tube and which serves to increase the inductance of the plate lead at the point where it is positioned to an extent sufficient to prevent occurrence of parasitic oscillations in the plate circuit.

2-9. FEEDBACK CIRCUITS. Degenerative voltage feedback used to improve the power amplifier stability and linearity is developed by the output transformer secondary winding that terminates at terminals 7 and 8 of T102. Terminal 7 is connected to ground and terminal 8 is connected to the control grid of V1A, as shown in Figure 4-3. Capacitor C7 and inductor L14, which are connected across this winding, serve to inhibit high frequency oscillations. Current-proportional feedback, provided to improve regulation over a wide range of load conditions, is developed across parallel-connected resistor R35 and ØA REG potentiometer R36, which are in series with one leg of the output circuit. The voltage developed across R35 and R36 is connected to the control grid of V1A through isolation transformer T1 and GAIN control R57. This second feedback circuit, which is regenerative, neutralizes a portion of the degenerative feedback under high load conditions. The current-proportional feedback voltage is adjusted to provide a minimum voltage variation between load and no-load conditions (or any two other specific conditions).

2-10. OUTPUT METER CIRCUIT. The output meter circuit, which includes a printed circuit meter board assembly and meter M101, provides continuous monitoring of the output voltage of the Invertron. The meter board assembly includes voltage-dividing and calibration resistors, and a full-wave bridge rectifier to convert the a-c output of the Invertron to d-c for application to the meter.

2-11. OUTPUT CIRCUIT OVERLOAD PROTECTION. Output circuit overload protection is provided by thermal circuit breaker CB101. An associated front-panel OVERLOAD lamp (DS1) lights to indicate that the circuit breaker has opened the output circuit. A RESET button on the front panel provides for the restoration of the Invertron output to the external load circuit.

2-12. MODEL 161A INTEGRAL POWER SUPPLY CIRCUITS

2-13. The integral power supply circuits (see Figure 4-3) provide all a-c and d-c voltages necessary to the operation of the 160 va power amplifier and the associated plug-in oscillator. These voltages and the circuits to which they are supplied are tabulated in Table 2-1.

TABLE 2-1

INTEGRAL POWER SUPPLY OUTPUTS

POWER SUPPLY OUTPUT	CIRCUITS TO WHICH SUPPLIED
6.3 vac output No. 1	Plug-in oscillator tube heater circuit
6.3 vac output No. 2	Heater of +300-volt voltage regulator series regulator tube V10
6.3 vac output No. 3	Heaters of +300-volt voltage regulator error amplifier tube V11 and tubes in the 160 va power amplifier
-105-volt bias potential	1. Phase inverter and cathode follower/driver tubes of the 160 va power amplifier 2. Plug-in oscillator
+300 volts	1. Plate circuits of phase inverter and cathode follower/driver tubes of the 160 va power amplifier 2. Screen grid circuits of push-pull output tubes of the 160 va power amplifier 3. Plug-in oscillator
+645 volts	1. Plate circuits of push-pull output tubes of the 160 va power amplifier 2. Input circuit of +300-volt voltage regulator

2-14. PRIMARY A-C POWER INPUT CIRCUIT. The primary a-c power is applied to step up/step down power transformer T101 through terminals 2 and 3 of TB101, fuse F101, and LINE ON switch S101. Transformer T101 provides the following outputs: the three 6.3 vac outputs listed in Table 2-1; 235 vac for application to the +645-volt voltage doubler circuit; 120 vac for application to the -105-volt bias supply circuit; and, 117 vac for application to the plug-in oscillator circuit and to OUTPUT ON indicator lamp DS102.

2-15. Primary A-C Power Input Voltage Range. The Invertron may be operated with primary a-c power inputs of 117 vac, 208 vac, 220 vac, or 230 vac. Each of these input voltages is accommodated by altering the connections to the primary windings of transformer T101. Refer to Table 3-1 and to the schematic diagram of Figure 4-3 for information concerning the connections to be made to the primary of T101 for each of the abovementioned a-c input voltages.

2-16. THE +645 VOLT POWER SUPPLY CIRCUIT. The +645-volt power supply is comprised of rectifiers CR1 through CR4 and capacitors C101 and C102, which are connected in a conventional full-wave voltage doubling rectifier and filter circuit that produces a d-c output of approximately +645 volts. The capacitors are large enough to maintain the output voltage at a value nearly equal to twice the peak value of the a-c voltage, and to provide all of the filtering that is required.

2-17. REGULATED POWER SUPPLY. The regulated power supply provides +300 volts for application to the phase inverters, cathode follower/drivers, and the screen grid circuits of the power amplifiers. The +300-volt regulator is comprised of series regulator tube V10, cascaded control amplifiers V11A and V11B, and associated circuit components. A reference voltage developed by neon lamp VR1 is applied to the grid of control amplifier tube V11B via resistors R52 and R53. Small changes in the regulator output voltage appear across resistors R49, R52, and R53, and are also applied to the grid of V11B. The regulation level is established by the setting of potentiometer R44.

2-18. BIAS POWER SUPPLY. The -105-volt bias power supply includes the 120 vac secondary (terminals 7 and 8) of transformer T101, half wave rectifier CR1, filter capacitors C8A and C8B, and gaseous voltage regulator tube V9. The power supply output is maintained by regulator tube V9 at -105 volts over a load current range of 5 through 35 milliamperes.

2-19. MODEL 503A INVERTRON CIRCUIT DESCRIPTION

2-20. The Model 503A Invertron (see Figures 2-2 and 4-4) consists essentially of a plug-in oscillator input and power circuit; three power amplifier circuits (which are the same as the Model 161A power amplifier circuits); output power monitoring and control circuits; and a primary a-c power input circuit. Refer to paragraphs 2-3 through 2-9 for information regarding operation of the power amplifier circuits, and refer to paragraphs 2-12 through 2-18 for a discussion of the power amplifier integral power supply circuits. These circuit descriptions relate directly to the "phase A" power amplifier of the Model 503A Invertron. The "phase B and C" power amplifier circuits are identical to the "phase A" circuit, therefore, the descriptions of paragraphs 2-3 through 2-9 and 2-12 through 2-18 will apply equally to the "phase B and C" power amplifiers.

2-21. OSCILLATOR INPUT AND POWER CIRCUITS. Connections between the Invertron and the oscillator are made via connectors J101/P101. The ØA, ØB, and ØC outputs of the oscillator are supplied to the related ØA, ØB, and ØC power amplifiers via contacts 1, 9, and 8, respectively, of J101/P101. A-c and d-c voltages necessary for operation of the oscillator are provided by the integral power supply circuits of the ØA power amplifier.

2-22. OUTPUT METER CIRCUIT. The output of each power amplifier is connected to the output meter circuit and, through contacts of OUTPUT ON switch S102, to the associated circuit breaker. The output meter circuit includes VOLTS OUT switch S103, the meter board assembly, and meter M101. Switch S101 enables selection of the phase, the output voltage of which is to be measured. The meter board assembly includes voltage-dividing and calibrating resistors, and a full wave bridge rectifier to convert the a-c output to d-c for application to meter M101.

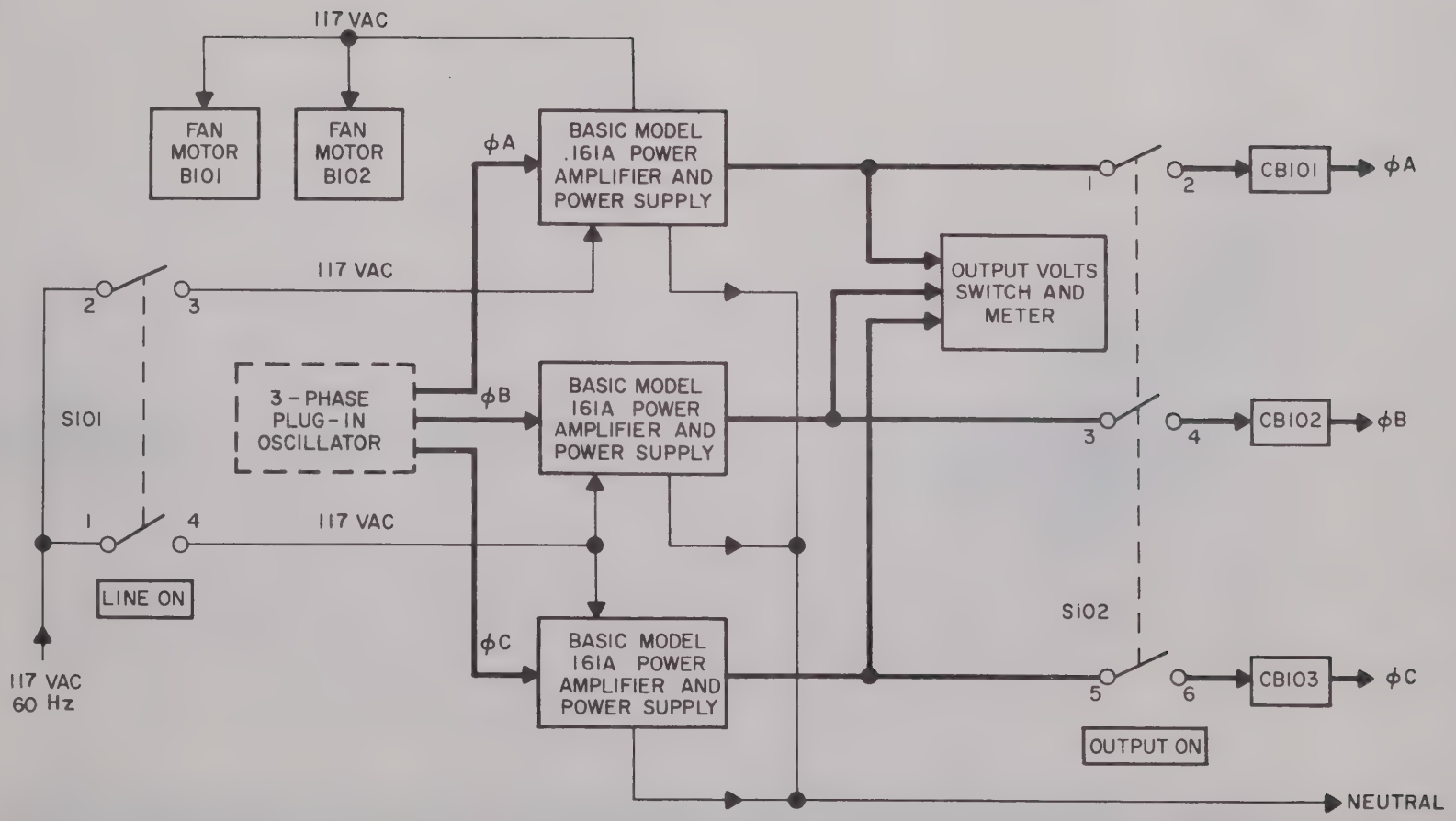


Figure 2-2. Model 503A Invertron, Block Diagram

2-23. OUTPUT CIRCUIT OVERLOAD PROTECTION. Each of the three output circuits is provided with independent overload protection. Circuit breakers CB101, CB102, and CB103 provide such protection for ØA, ØB, and ØC, respectively. Each circuit breaker is provided with an OVERLOAD indicator lamp which lights when the circuit breaker interrupts the circuit, and a front panel RESET button that provides for the restoration of power to the external load circuit.

2-24. PRIMARY A-C POWER INPUT CIRCUIT. The primary a-c power entering at terminal 1 of terminal board TB101 is connected to double-pole single-throw LINE ON switch S101 through fuse F101. Primary a-c power entering at terminal 2 of TB101 is connected to pin 1 of the step up/step down transformer (T101) in each of the three power amplifier circuits, and is also connected to one terminal of each of the fan motors (B101 and B102). The a-c circuit to the ØA amplifier is completed through contacts 2 and 3 of the LINE ON switch and the a-c circuit to the ØB and ØC amplifiers is completed through contacts 1 and 4 of the LINE ON switch.

2-25. PRIMARY A-C POWER INPUT VOLTAGE RANGE. The Model 503A Invertron will operate with primary power inputs of 117 vac, 208 vac, 220 vac, or 230 vac. Each voltage is accommodated by means of the connections made to the a-c power transformer (T101) of each power amplifier circuit. Refer to paragraph 2-15 for information regarding the procedure for making the necessary connections. The value of fuse F101 is 20 amperes for the 117 vac input. With the 208 vac, 220 vac, and 230 vac inputs, a 10-ampere fuse must be used for F101.

2-26. COOLING FANS. In the Model 503A Invertron, two cooling fans (B101 and B102) are employed. Operating power of 117 vac is supplied to these fans from a portion of the primary winding of power transformer T101 in the ØA power amplifier.

SECTION 3

OPERATION

3-1. GENERAL

3-2. This section provides operation instructions for the Model 161A and Model 503A Invertrons, which include those for plugging in or otherwise connecting an input signal source, making power input and output connections, preliminary adjustments, and normal operating procedures; refer to Figures 3-1 through 3-4. (In all cases, use of the name Invertron without qualification by model number indicates that the discussion applies equally to the Model 161A and the Model 503A Invertrons. Where the discussion applies specifically to one model, that model will be properly identified.)

WARNING

DO NOT TOUCH ELECTRONIC CIRCUITS WHEN THE INVERTRON IS ENERGIZED. THE INSTRUMENT GENERATES VOLTAGES DANGEROUS TO LIFE. IN PARTICULAR, AVOID CONTACT WITH THE HIGH-VOLTAGE POWER SUPPLY AND THE POWER AMPLIFIER PLATE CIRCUITS. ENSURE THAT THESE CIRCUITS HAVE BEEN GROUNDED BEFORE PERFORMING MAINTENANCE ON A DE-ENERGIZED INVERTRON.

3-3. INPUT SIGNAL SOURCE

3-4. Before attempting to operate the Invertron, make certain that a plug-in oscillator or other input signal source producing the desired frequency and phase combination is connected. Refer to Table 1-2 for types of plug-in oscillators available, and consult the relevent publication for the oscillator operating procedures. In the instructions which follow, it is assumed that the oscillator is automatically energized when the Invertron that it is plugged into is energized and that the Invertron output voltage can be adjusted by means of the oscillator OUTPUT VOLTS ADJUST control.

3-5. POWER INPUT AND POWER OUTPUT CIRCUIT CONNECTIONS. Before applying power to the Invertron, make certain that the a-c power source is of the proper voltage. As the Invertron is normally supplied, it is connected to operate on an input of 117-volts a-c. Should it become necessary to operate the Invertron from a-c power sources of 208, 220, or 230 volts, make connections to the primary of power transformer T101 as indicated in Table 3-1.

3-6. The primary a-c input power connections are made to AC POWER INPUT terminal board TB101, located on the rear portion of the Invertron chassis. The a-c connections are made to terminals 2 and 3 of TB101. Should it be required to ground one side of the a-c input to the Invertron chassis, connect a jumper between terminal 1 of TB101 and the proper terminal (2 or 3) of TB101.

3-7. Connections to the Model 161A Invertron output circuit may be made to the OUTPUT 160 VA binding posts on the front panel of the unit, or they may be made to HOT and N OUTPUT terminals 4 and 5 of terminal board TB101, located on the right rear portion of the chassis. The neutral side of the output circuit is connected to the white binding post on the front panel

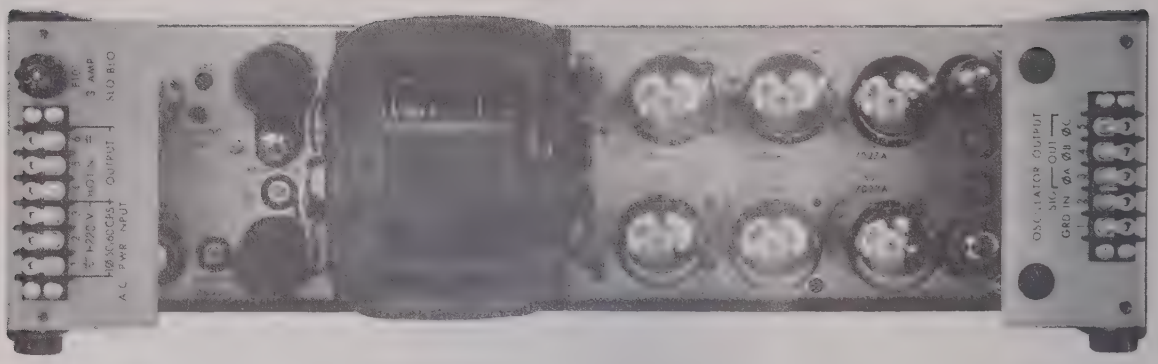


Figure 3-1. Model 161A Invertron, Rear View, Cover Removed

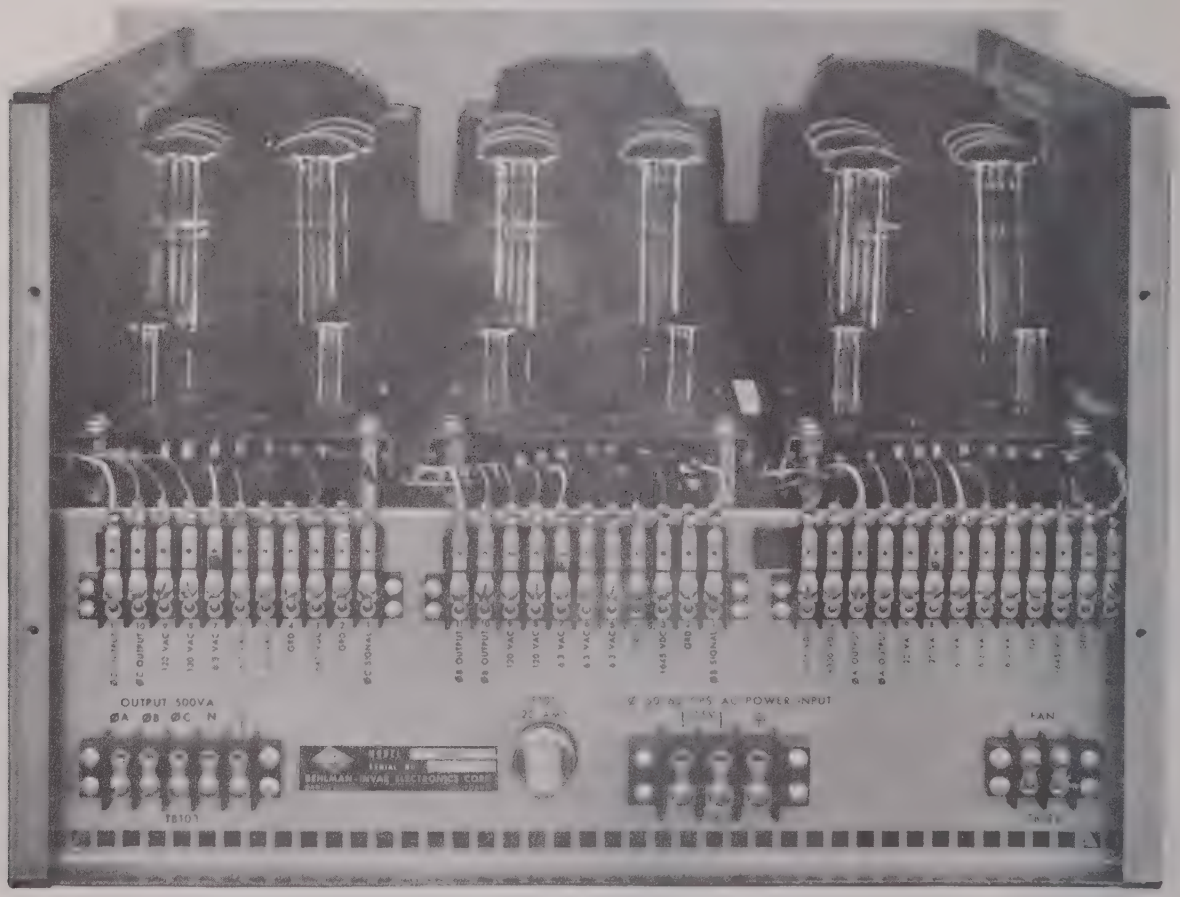


Figure 3-2. Model 503A Invertron, Rear View, Cover Removed

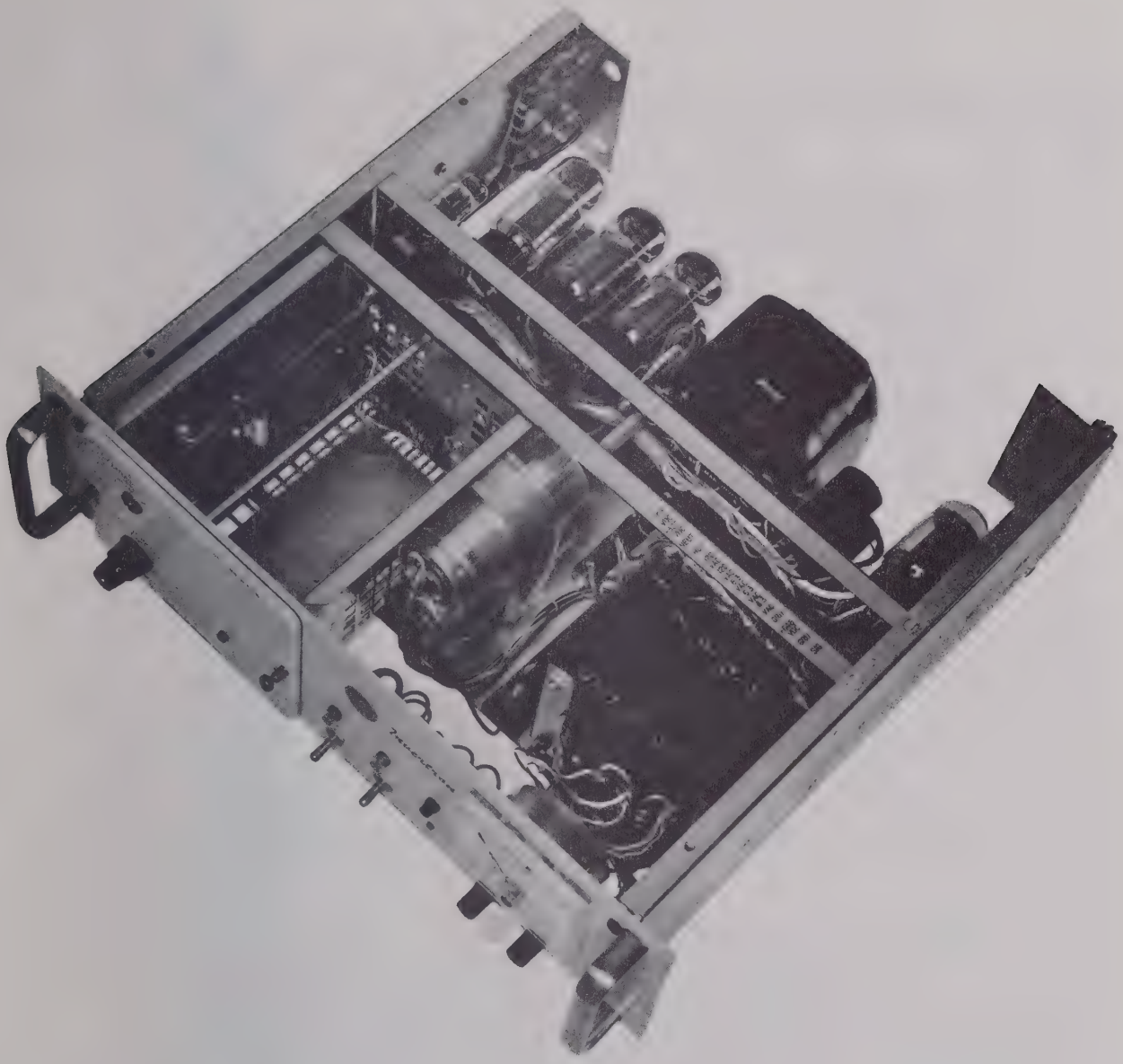


Figure 3-3. Model 161A Invertron, Top View, Cover Removed

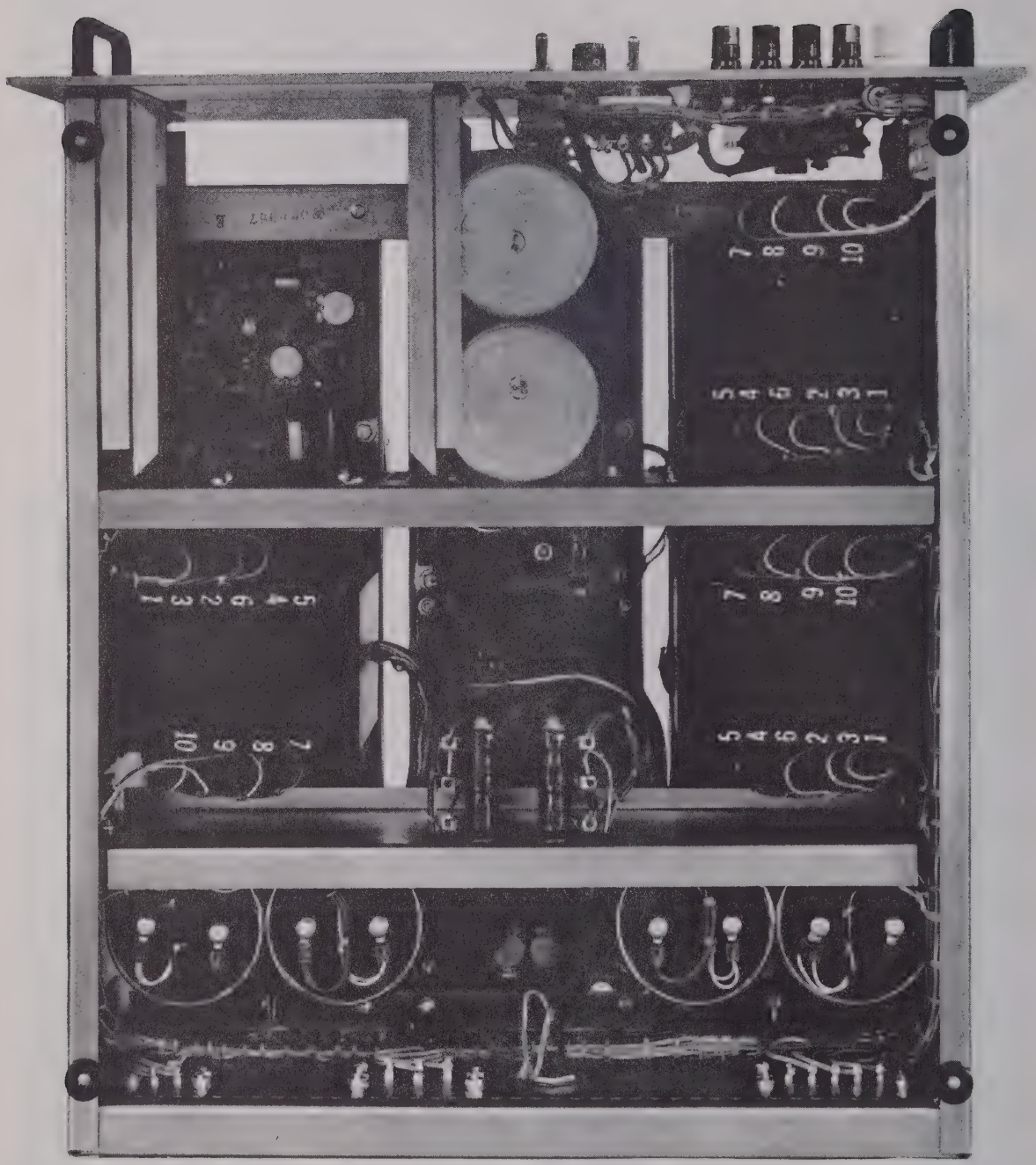


Figure 3-4. Model 503A Invertron, Bottom View

TABLE 3-1

TRANSFORMER T101 PRIMARY CIRCUIT CONNECTIONS
FOR DIFFERING AC INPUT VOLTAGES

NOTE:
1. Prior to changing connections on T101 primary windings to accommodate an a-c input other than 117 vac, REMOVE ALL EXISTING JUMPERS FROM THE PRIMARY OF T101.
2. When changing connection on T101 primary to accommodate a 117 vac input, be sure to REMOVE THE JUMPER CONNECTING TERMINALS 2 AND 3.
3. Model 161A: when a 117 vac input is used, the value of fuse F101 is 8 amperes. When an input other than 117 vac is used, the value of fuse F101 is 5 amperes.
4. Model 503A: when a 117 vac input is used, the value of fuse F101 is 20 amperes. When an input other than 117 vac is used, the value of fuse F101 is 10 amperes.

MODEL 161A INVERTRON

Input Voltage	Make Jumper Connection Between T101 Terminals:	Connect Lead from Terminal 2 of Line On Switch S101 to T101 Terminals:
115 vac	1 and 3 2 and 6	6
208 vac	2 and 3	4
220 vac	2 and 3	5
230 vac	2 and 3	6

MODEL 503A INVERTRON

Input Voltage	Make Jumper Connection Between T101 Terminals:	ØA POWER AMPLIFIER Connect Lead from Terminal 3 of Line On Switch S101 to T101 Terminals: ØB AND ØC POWER AMPLIFIERS Connect Lead from Terminal 4 of Line On Switch S101 to T101 Terminals:
115 vac	1 and 2 2 and 6	6
208 vac	2 and 3	4
220 vac	2 and 3	5
230 vac	2 and 3	6

and to the N terminal of TB101. A chassis ground connector is located adjacent to the neutral circuit connectors, and the neutral circuit may be grounded by connecting a jumper between the neutral and ground connectors.

3-8. Connections to the Model 503A Invertron output circuit may be made to the OUTPUT 500 VA A, B, and C binding posts on the front panel of the unit, or they may be made to the 500 VA ØA, ØB, and ØC terminals of terminal board TB103, located on the left rear portion of the chassis. Connection may be made to the neutral portion of the three phase circuit at the NEUT binding post on the front panel, or to the NEUT terminal of TB103. A chassis ground connector is located adjacent to both NEUT connection points, and the neutral circuit may be grounded by connecting a jumper between the NEUT connector and the ground connector.

3-9. CONTROLS AND INDICATORS

3-10. For a description of the controls on the plug-in oscillator, or other frequency-control signal source, refer to the appropriate manual for that equipment.

3-11. The front panel controls and indicators of the Invertrons (see Figure 1-1) and their respective functions are tabulated in Table 3-2.

CAUTION

Both the Model 161A and Model 503A Invertrons are provided with forced air ventilation. When power is applied to these units, make certain that the ventilating fans are operating. If the fans do not function, remove the a-c power immediately and correct the malfunction in the fan circuits.

TABLE 3-2

INVERTRON CONTROLS AND INDICATORS

NOTE: * indicates that item pertains to Model 161A Invertron only. ** indicates that item pertains to Model 503A Invertron only.	
LINE ON switch	Applies primary a-c power to Invertron.
LINE ON indicator lamp	Lights to indicate that primary a-c power is applied to Invertron.
OUTPUT ON switch	Connects Invertron output to Invertron output connectors.
OUTPUT ON indicator lamp	Lights to indicate that Invertron output is available at Invertron output connectors.
*OVERLOAD indicator lamp	Lights to indicate that circuit breaker is open.
**OVERLOAD indicator lamps A, B, and C	Lights to indicate that circuit breakers for A, B, and C phases are open.
*RESET pushbutton	Permits resetting circuit breaker.
**RESET pushbuttons A, B, and C	Permits resetting of phase A, B, and C circuit breakers.

TABLE 3-2

INVERTRON CONTROLS AND INDICATORS (Continued)

AC OUTPUT VOLTS meter	*Indicates rms output voltage of Invertron. **Indicates the rms output voltage of the phase selected by means of OUTPUT VOLTS switch.
**OUTPUT VOLTS switch	Permits connection of phase A, B, and C output to AC OUTPUT VOLTS meter.

3-12. PRELIMINARY CHECKS AND ADJUSTMENTS

3-13. Each Invertron is thoroughly adjusted and tested at the factory. However, since adjustments may become disturbed during shipping, the following checks and adjustments should be performed before placing the equipment in operation.

3-14. CHECKS AND ADJUSTMENTS OF THE MODEL 161A. Proceed as follows to check the Model 161A Invertron:

a. Place the LINE ON and OUTPUT ON switches in the "off" positions.

b. Turn the OUTPUT VOLTS ADJUST control on the oscillator fully counterclockwise.

c. Connect the Invertron to the primary power source and place the LINE ON switch in the ON position.

d. Observe that the LINE ON indicator lamp is lighted.

e. Place the OUTPUT ON switch in the ON position.

f. Observe that the OUTPUT ON indicator lamp is lighted and that the AC OUTPUT VOLTS meter indication is low.

g. Connect the positive lead of a 400-volt meter to the +300 VDC TEST point and connect the negative lead to the GRD test point.

h. Set the +300 VDC ADJUST control to produce a voltmeter indication of +300 volts.

i. Connect the positive lead of a 1-volt meter to A-1 BIAS TEST point and the negative lead to the GRD test point.

j. Set the A-1 BIAS ADJ control to produce a voltmeter indication of +0.3 volt.

k. Connect the positive meter lead to A-2 BIAS TEST point.

l. Set the A-2 BIAS ADJ control to produce a meter indication of +0.3 volt.

m. Turn the oscillator OUTPUT VOLTS ADJUST control clockwise until the Invertron AC OUTPUT VOLTS meter indicates 115 vac.

n. Place the OUTPUT ON switch in the "off" position.

o. Connect the proper load to the output terminals.

p. Place the OUTPUT ON switch in the ON position.

q. Set the REGULATION adjustment control to produce an AC OUTPUT VOLTS meter indication of 115 vac.

r. Repeat steps n through q until the two meter indications are within one percent of each other.

3-15. CHECKS AND ADJUSTMENTS OF THE MODEL 503A. Proceed as follows to check out the Model 503A Invertron:

a. Place the LINE ON and OUTPUT ON switches in the OFF positions.

b. Turn the OUTPUT VOLTS ADJUST control on the oscillator fully counterclockwise.

c. Connect the Invertron to the primary power source and place the LINE ON switch in the ON position.

d. Observe that the LINE ON indicator lamp is lighted.

e. Place the OUTPUT ON switch in the ON position.

f. Observe that the OUTPUT ON indicator lamp is lighted and that the AC OUTPUT VOLTS meter indication is low in all positions of the OUTPUT VOLTS switch.

g. Perform steps h through s for the phase A power amplifier.

h. Connect the positive lead of a 400-volt meter to the +300 VDC TEST point and connect the negative lead to the GRD test point.

i. Set the +300 VDC ADJUST control to produce a nominal voltmeter indication of +300 volts.

j. Connect the positive lead of a 1-volt meter to A-1 BIAS TEST point and the negative lead to the GRD test point.

k. Set the A-1 BIAS ADJ control to produce a voltmeter indication of +0.3 volt.

l. Connect the positive meter lead to A-2 BIAS TEST point.

m. Set the A-2 BIAS ADJ control to produce a meter indication of +0.3 volt.

n. Place the OUTPUT VOLTS switch in the A position, then turn the oscillator OUTPUT VOLTS ADJUST control clockwise until the Invertron AC OUTPUT VOLTS meter indicates 115 vac.

o. Place the OUTPUT ON switch in the "off" position.

p. Connect the proper load to the output terminals.

q. Place the OUTPUT ON switch in the ON position.

r. Set the REGULATION adjustment control to produce an AC OUTPUT VOLTS meter indication of 115 vac.

s. Repeat steps o through r until the two meter indications are within one percent of each other.

t. Repeat steps h through s for the phase B and C power amplifiers.

This completes the preliminary adjustment of the Model 503A Invertron.

3-16. OPERATING PROCEDURE

3-17. To operate the Invertron after the proper connections and preliminary adjustments have been made, follow the procedure described below.

a. Place the LINE ON and OUTPUT ON switches in the "off" positions, and rotate the oscillator OUTPUT VOLTS ADJUST control fully counterclockwise. If a variable frequency oscillator is used, set the oscillator frequency control to the desired frequency.

b. Connect the Invertron to the primary power source.

c. Connect the intended load to the appropriate output terminals.

d. Place the LINE ON switch in the ON position and allow the unit to warm up at least one minute.

e. Place the OUTPUT ON switch in the ON position.

f. Rotate the oscillator OUTPUT VOLTS ADJUST control clockwise until the AC OUTPUT VOLTS meter indicates the desired voltage.

3-18. When use of the Invertron is completed, turn the equipment off as follows:

a. Rotate the oscillator OUTPUT VOLTS ADJUST control fully counterclockwise.

b. Place the OUTPUT ON switch in the "off" position.

c. Place the LINE ON switch in the "off" position.

SECTION 4

MAINTENANCE

4-1. GENERAL

4-2. Careful and regular performance of periodic preventive maintenance upon the Invertron will reduce the probability of failure and the need for corrective maintenance. Refer to Figures 3-1 through 3-4 and Figures 4-1 through 4-4 as aids in the performance of maintenance upon the Invertron.

4-3. TEST EQUIPMENT

4-4. The test equipment required for adjusting and troubleshooting the Invertron is listed in Table 4-1.

TABLE 4-1

RECOMMENDED TEST EQUIPMENT

NOMENCLATURE	PART NO. OR MODEL	APPLICATION
Low Frequency Oscilloscope	Hewlett-Packard Model 120A/AR, or equivalent	Monitoring waveforms, general signal tracing
AC/DC Volt-Ohmmeter	Triplett Model 630A, or equivalent	General a-c voltage measurements D-c voltage measurements Resistance measurements

4-5. PERIODIC PREVENTIVE MAINTENANCE

4-6. INSPECTION. Perform routine inspection as follows:

PERIOD	AREA OF INSPECTION	ITEMS TO BE CHECKED
Weekly	Exterior of unit, particularly front and rear	Controls, indicators, connectors, wiring, and hardware for dust and dirt, insecurity of mounting or connection, and damage.
Monthly	Interior of unit, including individual assemblies	Electrical parts and wiring, (including printed circuit wiring) for dust, dirt, corrosion, and evidence of overheating and other damage.

4-7. CLEANING. Remove dust, dirt, and other foreign material as required, using low-pressure air whenever possible, supplementing this with the use of a brush or soft cloth and a suitable solvent when necessary.

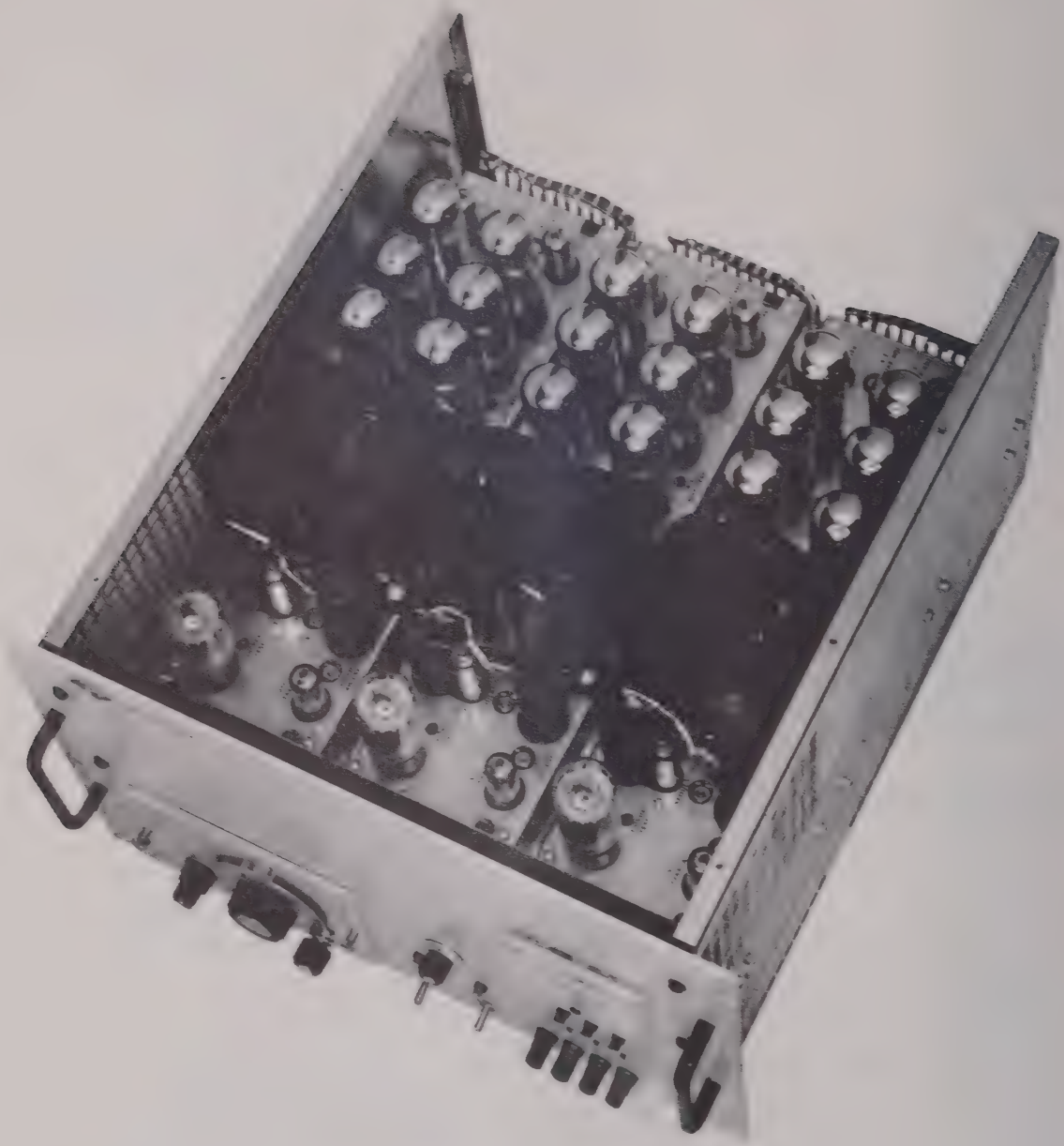


Figure 4-1. Model 503A Invertron, Top View, Cover Removed

Figure 4-2. Printed Circuit Board Assy, Part No. 4001843 (for Mod 161A and 503A)

CAUTION

Take care not to scratch the printed circuit wiring, if it is necessary to brush or rub it to remove foreign material.

WARNING

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT WHEN POWER IS APPLIED, PARTICULARLY IN THE PLATE CIRCUITS OF THE POWER SUPPLY AND AMPLIFIER. DO NOT PERFORM ADJUSTMENTS WHILE THE UNIT IS ENERGIZED UNLESS SUCH ADJUSTMENTS ARE ABSOLUTELY ESSENTIAL. WHEN MAKING ADJUSTMENTS, USE EXTREME CAUTION. PRIOR TO PERFORMING ADJUSTMENTS OR MAINTENANCE, DE-ENERGIZE THE UNIT, THEN GROUND ALL PLATE CIRCUITS AND HIGH VOLTAGE CAPACITORS.

4-8. OUTPUT VOLTAGE ADJUSTMENT. The output voltage of the Invertron is adjusted by means of the OUTPUT VOLTS ADJUST control on the plug-in oscillator, and this is part of the operating procedure, rather than maintenance, since the control is simply readjusted as required to keep the Invertron output voltage at the desired value. However, if the Invertron is to be used to supply the same output voltage for an extended period, noting the setting of this control and any changes required with the passing of time, can provide an indication of impending trouble in either the Invertron or the oscillator. If it is necessary to set this control to a series of different points to obtain the same output voltage as time passes, internal voltage measurements should be made on the Invertron and the oscillator to determine exactly which part of the circuit is changing.

NOTE

On the Model 503A Invertron, the power amplifier assemblies can be extended from the main chassis while still connected to that chassis through a cable. This arrangement facilitates circuit checking with power applied. The inclusion of this feature DOES NOT imply that the danger attendant to the high voltage circuits does not exist.

4-9. BIAS ADJUSTMENT. Bias adjustment of the power amplifier cathode follower/drivers should be checked periodically and readjusted to give minimum distortion of the Invertron output. Use an oscilloscope to check the waveform. This adjustment should be made when the Invertron is first installed, after the first month of use, after the second month, then every three or four months. A change in the required adjustment indicates a change in the characteristics of one or more of the tubes or other parts. Voltage and resistance measurement and tube checking should give a clue to the trouble.

4-10. MODEL 161A GAIN CONTROL ADJUSTMENT. The GAIN control, potentiometer R58, is factory-set to a nominal value and this setting should never require adjustment.

4-11. MODEL 503A GAIN ADJUSTMENTS. The GAIN controls, potentiometer R58, located on each power amplifier printed circuit board, are factory adjustments used on Model 503A to equalize the gains of the amplifiers for the three phases. These three controls should not require readjustment even if tubes or other parts in the circuit are replaced, provided that resistors in associated circuits are replaced with other resistors of the correct nominal value and proper 1% tolerance.

4-12. TROUBLESHOOTING

4-13. Troubleshooting techniques normally used for power supplies and audio amplifiers are appropriate for this equipment. The following information applies specifically to the Invertron.

4-14. VOLTAGE AND RESISTANCE MEASUREMENTS. Table 4-2 lists typical voltage and resistance measurements obtained between each tube socket terminal and ground. The equivalent measurements made upon any individual Invertron may differ to some extent from the values shown in Table 4-2, both as the result of minor differences between the Invertrons and as the result of variations in indications provided by various test instruments (even those of the same make and model). Therefore, it is recommended that, upon receipt of an Invertron, the measurements given in Table 4-2 be duplicated and the values thus obtained entered beside the corresponding typical readings provided in Table 4-2. The measurements were taken under the following conditions: Voltage, (1) No Load, (2) GAIN control(s) set at mid-range, and, (3) BIAS controls set for +0.3 volt bias on cathodes of V3 through V8; Resistance, (1) Power off and (2) All external connections removed.

TABLE 4-2

TUBE SOCKET TERMINAL VOLTAGE AND RESISTANCE MEASUREMENTS

Tube Type and Ref Des	Socket Terminal Number	Voltage Measurement	Resistance Measurement
7199	1	300 VDC	22K ohms
V1	2	145 VDC (nominal)	122K ohms
	3	108 VDC	60K ohms
	4	6.3 VAC (heater)	
	5	6.3 VAC (heater)	
	6	2.3 VDC	50K ohms
	7	Signal	1.9K ohms
	8	34.2 VDC	60K ohms
	9	17.5 VDC	2.3 megohms
7199	1	300 VDC	22K ohms
V2	2	145 VDC (nominal)	122K ohms
	3	108 VDC	60K ohms
	4	6.3 VAC (heater)	
	5	6.3 VAC (heater)	
	6	2.3 VDC	22K ohms

TABLE 4-2

TUBE SOCKET TERMINAL VOLTAGE AND RESISTANCE MEASUREMENTS (Continued)

Tube Type and Ref Des	Socket Terminal Number	Voltage Measurement	Resistance Measurement
	7	Signal	1.1 megohm
	8	34.2 VDC	60K ohms
	9	17.5 VDC	2.3 megohms
7027A	1	300 VDC	25K ohms
V3, V4, V5, V6, V7, V8	2	6.3 VAC (heater)	
	3	670 VDC	22.5K ohms
	4	300 VDC	25K ohms*
	5	34 VDC	60K ohms
	6	34 VDC	60K ohms*
	7	6.3 VAC (heater)	
	8	0.3 VDC	10 ohms
OB2	1		3.3K ohms*
V9	2		0*
	3		NC
	4		0*
	5		3.3K ohms*
	6		3.3K ohms
	7		0
6L6GC	1	670 VDC	25K ohms*
V10	2	300 VDC	25K ohms
	3	670 VDC	20K ohms
	4	670 VDC	25K ohms
	5	280 VDC	750K ohms
	6	280 VDC	750K ohms*
	7	300 VDC	25K ohms
	8	300 VDC	25K ohms

* Indicates resistance is infinite when measurement made with tube removed from socket.

TABLE 4-2

TUBE SOCKET TERMINAL VOLTAGE AND RESISTANCE MEASUREMENTS (Continued)

Tube Type and Ref Des	Socket Terminal Number	Voltage Measurement	Resistance Measurement
12AX7A	1	280 VDC	700K ohms
V11	2	155 VDC	700K ohms
	3	155 VDC	28K ohms
	4	6.3 VAC (heater)	
	5	6.3 VAC (heater)	
	6	155 VDC	700K ohms
	7	58 VDC	1.1 megohms
	8	60 VDC	16.5K ohms
	9	0	

4-15. CIRCUIT FAULTS NOT AFFECTING VOLTAGE AND RESISTANCE MEASUREMENTS. Generally speaking, open capacitors, and certain other open parts, if they are in series with capacitors, will not affect d-c voltage and resistance measurements. These failures, however, usually are indicated by other symptoms. For example, the parts listed in Table 4-3, if open, will produce the indicated symptoms.

TABLE 4-3

TYPICAL COMPONENT FAILURE SYMPTOMS

OPEN PART	SYMPTOM
C1 in amplifier on Printed Circuit Board Assy	Oscillation
C4	Reduced gain in both halves of phase inverter
C2 or C3	Reduced signal to corresponding cathode follower, and increased distortion in amplifier output
C7, R57 or L14 in output circuit	Oscillation
C9 in power supply series regulator circuit	Increased ripple in +300 vdc output
C11	Noise in output and poor regulation
C12, R54	Noise in +300 vdc output

In addition to the open parts listed above, another functional defect which may not have a substantial effect on any d-c measurement is mismatch between the tubes in the two halves of a phase inverter (for example, V1A and V2A). This mismatch will cause higher distortion in the output of the amplifier.

4-16. REPAIR AND REPLACEMENT. When reconnecting or replacing electrical parts, observe the usual standards of good practice, paying particular attention to the following points:

a. Use exact equivalent parts, as described in the parts list, Section 5.

b. Place parts and wiring in same locations as before repair.

c. Take care to avoid damage, particularly by burning insulation, scratching or breaking printed wiring, or pinching wires.

d. When replacing parts on printed circuit boards, do not attempt to unsolder them; clip the leads to the part to be removed, and solder the new part to the portions of the leads which remain connected to the board.

4-17. LUBRICATION. The fan motors used in the Invertron power supplies will give reliable performance from 2 to 5 years under favorable conditions of temperature and vibration without the necessity of oiling: the life of the motors being in reverse proportion to these factors. For example, at 110°F the fans may be expected to give reliable performance for more than three years and, at 40°F, reliable performance is extended beyond five years. If the equipment is installed in environments of greater heat, or severe vibration, the fan motor life may be extended by periodic oilings (applying a small amount of lubricant once per year).

4-18. LUBRICATION OF MODEL 161A FAN MOTOR. The fan is located on the rear portion of the Model 161A Invertron protective housing. There are two small oil holes in each motor shaft bearing support. Each time that the motor is to be oiled, place a drop or two of light machine oil in either of the oil holes in each bearing support.

4-19. LUBRICATION OF MODEL 503A FAN MOTORS. An oil injector is required to lubricate the two "Muffin" fans mounted at the rear of the protective housing of the Model 503A Invertron. The Oil Injector may be obtained from the fan manufacturer, Rotron Manufacturing Co., Inc., Woodstock, New York. This oil injector will service from 15 to 20 fan motors. For lubricant refills, order Muffin Fan Lubricant. The procedure for oiling is as follows:

1. Remove cap from end of oil injector.

2. Place needle at center of circle marked in the letter "O" of the word "OIL" on the gold label to the rear of the fan.

3. Position the needle at an angle of approximately 45° to the surface of the label and tangent to the perimeter of the circle.

4. Pierce the label and the concealed self-sealing rubber cap located under the label, inserting the needle approximately 1/4 inch.

5. Depress the plunger of the oil injector slowly to the next calibration mark. Then withdraw the needle.

NOTE

It is better to inject a little more oil than not enough; however, do not overflow the well.

If the ambient temperatures are extremely high, it may be advisable to oil the motor more frequently to insure the optimum performance characteristics of the fan.

4-20. SHUT-DOWN PROCEDURE. When the Invertron is to be shut down for an extended period of time, no special precautions need to be taken except covering the equipment so it will not collect dust.

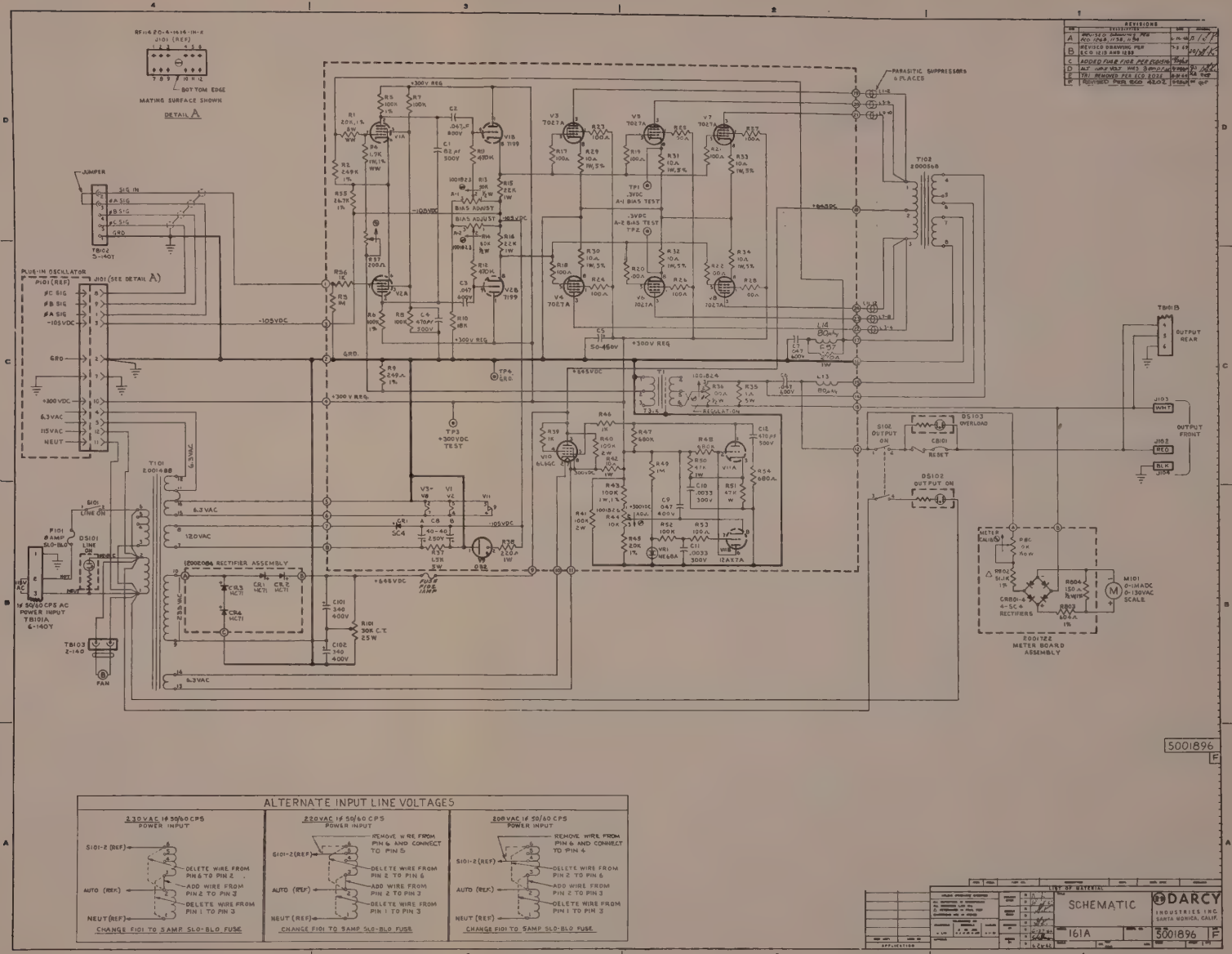

ALTERNATE INPUT LINE VOLTAGES
230 VAC 1ϕ 50/60 CPS POWER INPUT
S101-2 (REF)
AUTO (REF.)
NEUT (REF.)
DELETE WIRE FROM PIN 6 TO PIN 2
ADD WIRE FROM PIN 2 TO PIN 3
DELETE WIRE FROM PIN 1 TO PIN 3
CHANGE F101 TO 3AMP SLO-BLO FUSE
220 VAC 1ϕ 50/60 CPS POWER INPUT
REMOVE WIRE FROM PIN 6 AND CONNECT TO PIN 5
DELETE WIRE FROM PIN 2 TO PIN 6
ADD WIRE FROM PIN 2 TO PIN 3
DELETE WIRE FROM PIN 1 TO PIN 3
CHANGE F101 TO 3AMP SLO-BLO FUSE
208 VAC 1ϕ 50/60 CPS POWER INPUT
REMOVE WIRE FROM PIN 6 AND CONNECT TO PIN 4
DELETE WIRE FROM PIN 2 TO PIN 6
ADD WIRE FROM PIN 2 TO PIN 3
DELETE WIRE FROM PIN 1 TO PIN 3
CHANGE F101 TO 3AMP SLO-BLO FUSE
SCHEMATIC
161A
DARCY
INDUSTRIES INC.
SANTA MONICA, CALIF.
5001896
F

Figure 4-3. Model 161A Invertron, Schematic Diagram

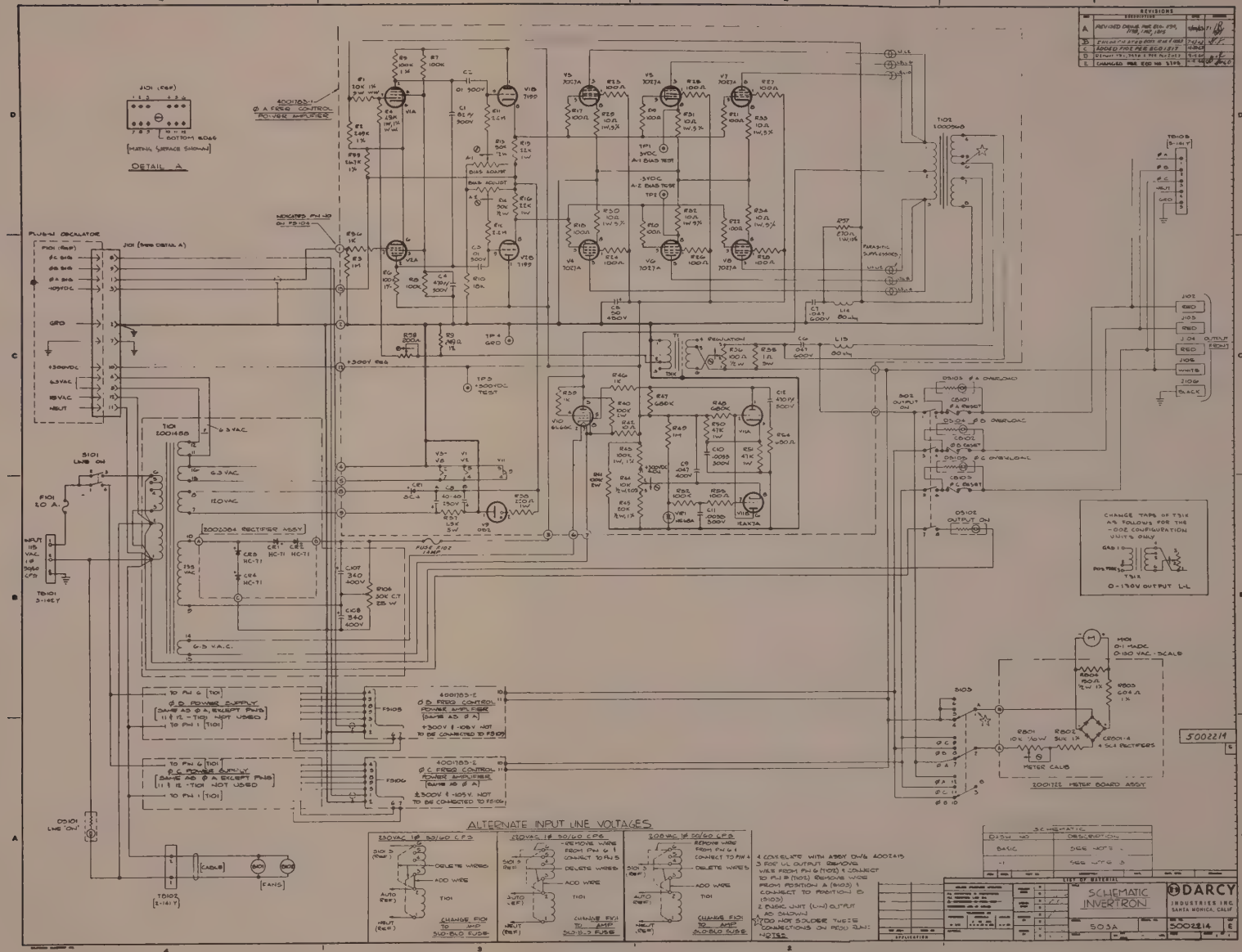


Figure 4-4. Model 503A Invertron, Schematic Diagram

SECTION 5

PARTS LIST

5-1. INTRODUCTION

5-2. This section provides information necessary to procure replacements for all of the electrical parts in the equipment. Note that the Model 161A and Model 503A listings apply only to these respective models, whereas, the listings for the Power Amplifier Printed Circuit Board Assy (Part No. 4001909) and the Meter Printed Circuit Board Assy (Part No. 2001722) apply to both models.

5-3. VENDORS' CODES. Approved vendors' codes, as listed in Federal Cataloging Handbook H4-1, are used in this parts list and are listed below in numerical sequence.

CODE	VENDOR'S NAME AND ADDRESS
01179	Ajax Magnethermic Corp. Warren, Ohio
01295	Texas Instruments, Inc. Dallas, Texas
02799	Arco Capacitors, Inc. Los Angeles, Calif.
03797	Eldema Corp. Compton, Calif.
04009	Arrow-Hart and Hegeman Electric Co. Hartford, Conn.
04746	Behlman-Invar Electronics Corp. Santa Monica, Calif.
06915	Richco Plastic Co. Chicago, Ill.
08984	Mel-Rain Corp. Indianapolis, Indiana
11897	Plastiglide Co. Santa Monica, Calif.
12406	Elpac Inc. Fullerton, Calif.
12974	Electro Capacitors Co. Oakland, Calif.
13327	Solitron Devices, Inc. Tappan, N.Y.
14099	Semtech Corp. Newbury Park, Calif.
14193	California Resistor Co. Santa Monica, Calif.
14752	Electro Cube San Gabriel, Calif.
16327	Dayton Electric Mfg. Co. Chicago, Ill.
24446	General Electric Co. Schenectady, N.Y.
27191	Cutler-Hammer Inc. Milwaukee, Wis.
31356	J.B.T. Instrument Inc. New Haven, Conn.
44655	Ohmite Mfg. Co. Skokie, Ill.
49956	Raytheon Co. Lexington, Mass.
53021	Sangamo Electric Co. Springfield, Ill.

CODE	VENDOR'S NAME AND ADDRESS
56289	Sprague Electric Co. North Adams, Mass.
58474	Superior Electric Co. Bristol, Conn.
71400	Bussmann Mfg. Div. of McGraw-Edison Co. St. Louis, Mo.
71590	Centralab Div. of Globe- Union, Inc. Milwaukee, Wis.
71785	Cinch Mfg. Co. and Howard B. Jones Div. Chicago, Ill.
72982	Erie Technological Products, Inc. Erie, Pa.
75915	Littelfuse Inc. Des Plaines, Ill.
80126	Pacific Electricord Co. Gardena, Calif.
81095	Triad Transformer Corp. Venice, Calif.
82877	Rotron Mfg. Co., Inc. Woodstock, N.Y.
83330	Herman H. Smith, Inc. Brooklyn, N.Y.
83827	Resistors, Inc. Chicago, Ill.
91637	Dale Electronics, Inc., Columbus, Neb.
91662	Elco Corp. Willow Grove, Pa.
94312	National Moldite Co. Newark, N.J.
00000	Any Standard RETMA tube Dealer

REF DES	PART NO.	1 2 3 4 DESCRIPTION	QTY	MFR CODE
	5001788	Main Assy, Model 161A	Ref	04746
B1	3M039	. MOTOR, AC, cooling fan	1	16327
C101,C102	32D2241T	. CAPACITOR, FIXED, ELECTROLYTIC, 340 µf, 400 wvdc or	2	56289
	43F957CA6	. CAPACITOR, FIXED, ELECTROLYTIC, 350 µf, 400 wvdc or	2	24446
	539-2592-01	. CAPACITOR, FIXED, ELECTROLYTIC, 350 µf, 400 wvdc or	2	53021
	NV450J.3.5	. CAPACITOR, FIXED, ELECTROLYTIC, 350 µf, 450 wvdc.	2	12974
CB101	2.0 AMP	. CIRCUIT BREAKER, 2.0 amp break current	1	08984
(0-30v)	8.5 AMP	. CIRCUIT BREAKER, 8.5 amp break current	1	08984
	4.0 AMP	. CIRCUIT BREAKER, 4.0 amp break current (for 3Ø, L-L application only)	1	08984
CR1 thru CR4	HC71	. SEMICONDUCTOR DEVICE, DIODE . . .	1	13327
DS101, DS102	BG03-AC-B-NE2H-33K	. LAMP, INDICATOR, amber.	2	03797
DS103	BG03-RC-B-NE2H-33K (for Std units)	. LAMP, INDICATOR, red	1	03797
DS103 (0-30v)	BF03-RT-B-1762	. LAMP, INDICATOR, red	1	03797
	1003237 (for 3Ø, L-L application only)	. LAMP, INDICATOR, red	1	04746
F101	313008	. FUSE, CARTRIDGE, 8 amp (3AG slo-blo) for 115 vac input.	1	75915
	313003	. FUSE, CARTRIDGE, 5 amp (3AG slo-blo) for 208, 220, and 230 vac inputs	1	75915
F102	HVA-1AMP	. FUSE, CARTRIDGE, 1 amp	1	71400
J101	RF11420-4-1414-1H-X	. CONNECTOR, RECEPTACLE, ELECTRICAL	1	91662
J102	DF31RC	. POST, BINDING, red	1	58474
J103	DF31WTC	. POST, BINDING, white	1	58474
J104	DF31BC	. POST, BINDING, black.	1	58474

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
L101 thru L112	M-315	CHOKE, PARASITIC SUPPRESSOR.	12	94312
M101	2500006-1	VOLTMETER, 0-130 vac scale	1	04746
(0-30v)	2500006-12	VOLTMETER, 0-30 vac scale	1	04746
R101	Type 2B	RESISTOR, FIXED, WIREWOUND, 30K, c.t., 25w	1	83827
S101	MS25306-22S	SWITCH, TOGGLE, SPST	1	27191
S102	ST52K	SWITCH, TOGGLE, DPST.	1	31356
T101	2001488	TRANSFORMER, POWER, STEP-DOWN AND STEP-UP	1	04746
T102	2000568	TRANSFORMER, AUDIO FREQUENCY, power output	1	04746
(0-30v)	2001338	TRANSFORMER, AUDIO FREQUENCY, power output	1	04746
TB101	353-18-06-001	TERMINAL BOARD, 6 term	1	71785
TB102	353-18-05-001	TERMINAL BOARD, 5 term	1	71785
TB103	353-11-02-001	TERMINAL BOARD, 2 term	1	71785
TB104	353-18-13-001	TERMINAL BOARD, 13 term	1	71785
V1,V2	7199	ELECTRON TUBE.	2	00000
V3 thru V8	7027A	ELECTRON TUBE.	6	00000
V9	OB2	ELECTRON TUBE.	1	00000
V10	6L6GC	ELECTRON TUBE.	1	00000
V11	12AX7A	ELECTRON TUBE.	1	00000
XF101	342004	FUSEHOLDER	1	75915
XF102	4528	FUSEHOLDER	1	71400
	4001909	PRINTED CIRCUIT BOARD ASSY, power amplifier (see breakdown below).	1	04746
	2001722	PRINTED CIRCUIT BOARD ASSY, meter (see breakdown below)	1	04746
	HKP-3	COVER, CAPACITOR, insulating cover for C5.	1	56289
	HKP-1	COVER, CAPACITOR, insulating cover for C8.	1	56289
	0-1803-076GY	AC LINE CORD, 3-conductor, with integral 3-pin (grounding) plug. .	1	80126
	101-11-1012	FOOT, PLASTIC	4	11897

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
	4002085	. COVER, TOP	1	04746
	4002415	Main Assy, Model 503A	Ref	04746
		NOTE Components of the power supply and power amplifier for each of the 3 phases are identical, with the corresponding components of each phase having the same reference designations. In the following portion of the parts list, each reference designation in the REF DES column that is shared by 3 components is preceded by an asterisk (*).		
B101,B102		. GOLD SEAL MUFFIN "VENTURI FAN" .	2	82877
*C107, *C108	43F959CA6	. CAPACITOR, FIXED, ELECTROLYTIC, 340 µf, 400 wvdc	6	24446
CB101, CB102, CB103	2.0 AMP	. CIRCUIT BREAKER, 2.0 amp break current	3	08984
(0-30v)	8.5 AMP	. CIRCUIT BREAKER, 8.5 amp break current	3	08984
	4.0 AMP	. CIRCUIT BREAKER, 4.0 amp break current (for 3Ø, L-L application only)	3	08984
*CR1 thru *CR4	HC71	. SEMICONDUCTOR DEVICE, DIODE . . .	12	13327
DS101, DS102	BG03-AC-B-NE2H-33K	. LAMP, INDICATOR, amber	2	03797
DS103,104, 105	BG03-RC-B-NE2H-33K (for Std. units)	. LAMP, INDICATOR, red	3	03797
DS103 (0-30v)	BF03-RT-B-1762	. LAMP, INDICATOR, red	1	03797
DS103,104, 105	1003237 (for 3Ø, L-L application only)	. LAMP, INDICATOR, red	3	04746
F101	314020	. FUSE, CARTRIDGE, 20 amp (for 115 vac input)	1	75915
	314010	. FUSE, CARTRIDGE, 10 amp (for 208, 220, and 230 vac input)	1	75915
F102	HVA-1AMP	. FUSE, CARTRIDGE, 1 amp	1	71400
J101	RF11420-4-1414-1HX	. CONNECTOR, RECEPTACLE, ELECTRICAL	1	91662

PARTS LIST (Continued)

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
J102, J103, J104	DF31RC	POST, BINDING, red	3	58474
J105	DF31WTC	POST, BINDING, white	1	58474
J106	DF31BC	POST, BINDING, black	1	58474
M101	2500006-1	VOLTMETER, 0-130 va scale	1	04746
M101 (0-30v)	2500006-12	VOLTMETER, 0-30 va scale	1	04746
*R106	Type 2B	RESISTOR, FIXED, WIREWOUND, 30k, c.t., 25w	3	83827
S101	MS25307-22	SWITCH, TOGGLE, DPST	1	27191
S102	82632	SWITCH, TOGGLE, 4PST	1	04009
S103	PA-1007	SWITCH, ROTARY, 3P3T	1	83330
*T101	2001488	TRANSFORMER, POWER, STEP-DOWN AND STEP-UP	3	04746
TB101	355-18-03-001	TERMINAL BOARD, 3 term	1	71785
TB102	354-18-02-001	TERMINAL BOARD, 2 term	1	71785
TB103	354-18-05-001	TERMINAL BOARD, 5 term	1	71785
TB104	353-18-13-001	TERMINAL BOARD, 13 term	1	71785
TB105, TB106	353-18-11-001	TERMINAL BOARD, 11 term	2	71785
*V1, *V2	7199	ELECTRON TUBE	6	00000
*V3 thru *V8	7027A	ELECTRON TUBE	18	00000
*V9	OB2	ELECTRON TUBE	3	00000
*V10	6L6GC	ELECTRON TUBE	3	00000
*V11	12AX7A	ELECTRON TUBE	3	00000
XF101	344125	FUSEHOLDER	1	75915
XF102	4528	FUSEHOLDER	1	71400
XS103	2001491	KNOB, L-N application	1	04746
	2001492	KNOB, L-L application	1	04746
	4001909	PRINTED CIRCUIT BOARD ASSY, power amplifier (see breakdown below)	1	04746
	2001722	PRINTED CIRCUIT BOARD ASSY, meter (see breakdown below)	1	04746
	HKP-3	COVER, CAPACITOR, insulating cover for C5	3	56289

PARTS LIST (Continued)

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
	HKP-1	. COVER, CAPACITOR, insulating cover for C8	3	56289
	0-1803-076GY	. AC LINE CORD, 3-conductor, with integral (grounding) plug	1	80126
	101-11-1012	. FOOT, PLASTIC	4	11897
	3000973	. COVER, TOP	1	04746
	4001909	Printed Circuit Board Assy	Ref	04746
C1	CM-15-E-820J	. CAPACITOR, FIXED, MICA DIELECTRIC, 82 µµf ±5%, 500 wvdc	1	02799
C2,C3	210C1F473	. CAPACITOR, MET. MYLAR, 0.047 µf ±20%, 600 wvdc	2	14752
C4,C12	CM-15-E-471J	. CAPACITOR, FIXED, CERAMIC DIELECTRIC, 470 µµf, ±5%, 300 wvdc	2	02799
C5	TVL 1728	. CAPACITOR, FIXED, ELECTROLYTIC, 50 µf, 450 wvdc	1	56289
C6,C7		. CAPACITOR, FIXED, PLASTIC DIELECTRIC, 0.047 µf ±20%, 600 wvdc.	2	01179
C6 (0-30v)	Not Used			
C8	TVL 2520	. CAPACITOR, FIXED, ELECTROLYTIC, 40/40 µf ±20%, 250 wvdc	1	56289
C9	ZD4A473	. CAPACITOR, FIXED, PLASTIC DIELECTRIC, 0.047 µf ±20%, 400 wvdc.	1	12406
C10,C11	801Z5V332	. CAPACITOR, FIXED, CERAMIC DIELECTRIC, 0.0033 µf ±20%, 500 wvdc	2	72982
CR1	SC 4	. SEMICONDUCTOR DEVICE, DIODE	1	14099
L13,L14	3000605-20	. CHOKE, 80 µhy	2	04746
L13 (0-30v)	Not Used	Substitute jumper		
R1	RH-5-20K	. RESISTOR, FIXED, WIREWOUND, 20K ±1%, 5w	1	91637
R2	CD1/2MR-249K	. RESISTOR, FXD, FILM, 249K±1%, 1/2w.	1	01295
R3,R49	RC20GF105J	. RESISTOR, FIXED, COMPOSITION, 1 meg, ±5%, 1/2w	2	MIL-R-11
R4	RS-1A-1.9K	. RESISTOR, FIXED, WIREWOUND, 1.9K ±1%, 1w	1	91637

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
R5,R6	CD1/2MR-100K	RESISTOR, FIXED, FILM, 100K ±1%, 1/2w	2	01295
R7,R8, R52	RC20GF104J	RESISTOR, FIXED, COMPOSITION, 100K ±5%, 1/2w	3	MIL-R-11
R9	CD1/2MR-249 ohms	RESISTOR, FIXED, FILM, 249 ohms ±1%, 1/2w	1	01295
R9 (0-30v)	CD1/2MR-500 ohms	RESISTOR, FIXED, FILM, 500 ohms ±1%, 1/2w	1	01295
R10	RC20GF183J	RESISTOR, FIXED, COMPOSITION, 18K ±5%, 1/2w	1	MIL-R-11
R11,R12	RC20GF474J	RESISTOR, FIXED, COMPOSITION, 470K ±5%, 1/2w	2	MIL-R-11
R13,R14	1001823	POTENTIOMETER, COMPOSITION, 50K ±20%, 1/2w	2	04746
R15,R16	RC32GF223K	RESISTOR, FIXED, COMPOSITION, 22K ±10%, 1w	2	MIL-R-11
R17 thru R28,R53	RC20GF101J	RESISTOR, FIXED, COMPOSITION, 100 ohms ±5%, 1/2w	13	MIL-R-11
R29 thru R34,R42	RC32GF100J	RESISTOR, FIXED, COMPOSITION, 10 ohms ±5%, 1w	7	MIL-R-11
R35	4530	RESISTOR, FIXED, WIREWOUND, 1 ohm ±5%, 5w	1	44655
R35 (0-30v)	MC250	RESISTOR, FIXED, WIREWOUND, .15 ohms ±3%, 25w	1	14193
R36	1001824	POTENTIOMETER, COMPOSITION, 100 ohms ±20%, 1/2w	1	04746
R37	4627	RESISTOR, FIXED, WIREWOUND, 1.5K ±5%, 5w	1	44655
R38	RC32GF221K	RESISTOR, FIXED, COMPOSITION, 220 ohms ±10%, 1w	1	MIL-R-11
R39,R46, R56	RC20GF102J	RESISTOR, FIXED, COMPOSITION, 1K ±5%, 1/2w	3	MIL-R-11
R40,R41	RC42GF104K	RESISTOR, FIXED, COMPOSITION, 100K ±10%, 2w	2	MIL-R-11
R43	CD1MR-100K	RESISTOR, FIXED, FILM, 100K ±1%, 1 w	1	01295
R44	1001826	POTENTIOMETER, COMPOSITION, 10K ±20%, 1/2w	1	04746
R45	CD1/2MR-20K	RESISTOR, FIXED, FILM, 20K ±1%, 1/2w	1	01295

PARTS LIST (Continued)

REF DES	PART NO.	DESCRIPTION 1 2 3 4	QTY	MFR CODE
R47,R48		. RESISTOR, FIXED, COMPOSITION, 680K ±20%, 1/2w	2	44655
R50,R51	RC32GF473K	. RESISTOR, FIXED, COMPOSITION, 47K ±10%, 1w	2	MIL-R-11
R54	RC20GF681K	. RESISTOR, FIXED, COMPOSITION, 680 ohms ±10%, 1/2w	1	MIL-R-11
R55	CD1/2MR-26.7K	. RESISTOR, FIXED, FILM, 26.7K ±1%, 1/2w	1	01295
R57	RC32GF271K	. RESISTOR, FIXED, COMPOSITION, 270 ohms ±10%, 1w	1	MIL-R-11
R58	1002714	. POTENTIOMETER, COMPOSITION, 200 ohms	1	04746
T1	T31X	. TRANSFORMER, AUDIO FREQUENCY, regulation feedback	1	81095
TP1,TP2, TP3	276-1564G4	. JACK, TIP, red	3	49956
TP4	276-1564G6	. JACK, TIP, black	1	49956
VR1	NE-68A	. LAMP, GLOW	1	24446
XL13, XL14	E-10	. CLAMP	2	06915
XV1, XV2, XV11	44P24033	. SOCKET, ELECTRON TUBE, 9 pins	3	71785
XV3 thru XV8, XV10	51P24002	. SOCKET, ELECTRON TUBE, 8 pins	7	71785
XV9	53P24034	. SOCKET, ELECTRON TUBE, 7 pins	1	71785
	2001722	Meter Board Printed Circuit Assy	Ref	04746
(0-30v)	2002345	Meter Board Printed Circuit Assy	Ref	04746
CR801 thru CR804	SC 4	. SEMICONDUCTOR DEVICE, DIODE . . .	4	14099
R801	B16-115	. POTENTIOMETER, COMPOSITION, 10K, 1/10w	1	71590
R802	CD1/2MR	. RESISTOR, FIXED, FILM, carbon, 51.1K ±1%	1	01295
R803	CD1/2MR	. RESISTOR, FIXED, FILM, 604 ohms ±1%.	1	01295
R804	CD1/2MR	. RESISTOR, FIXED, FILM, 150 ohms ±1%.	1	01295

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS CORPORATION warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are tubes, fuses, and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS CORPORATION will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned to the Company freight prepaid, and when examination reveals that the fault has not occurred because of misuse or abnormal conditions of operation. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALICO will submit an estimate for such charges before commencing repair if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALICO or its local representative, giving full details of the difficulty, and including the model number and serial number. On receipt of this information, service data or shipping instructions will be furnished. If shipment is indicated, forward the instrument, freight prepaid, to the authorized repair station indicated in the instruction. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the warranty.

DAMAGE IN TRANSIT

The instrument should be tested as soon as it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to us. CALICO will advise the disposition to be made of the equipment and arrange for repair or replacement. Please include model number and serial number when referring to the instrument.

MP MASTER
MA28329